DYNAMIC ORDER QUANTITY – AN ALTERNATIVE TO ECONOMIC ORDER QUANTITY

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August 1988

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Overpricing by DoD vendors and the Competition in Contracting Act forced the Military Services and the Defense Logistics Agency (DLA) to re-examine their basic inventory management and procurement methods for spares and repair parts. To take advantage of price reductions associated with purchasing larger quantities and to offset growing procurement workload and administrative leadtimes, they increased their minimum order quantities from 3-months' supply to 12-months' supply.

That policy shift brought both costs and benefits. On the positive side, it brought about price breaks on selected items and reduced overall procurement replenishment workload by about 20 percent. On the negative side, order quantity requirements have doubled since FY83, annual costs to the DoD to hold that additional inventory have increased by more than $600 million, and inapplicable assets have grown by over $4 billion – an 86 percent increase. On balance, the DoD order quantity strategy has proved extremely costly and should be reversed because more effective avenues exist to deal with both price/quantity discounts and procurement workload without incurring significant investment costs. We recommend that the Assistant Secretary of Defense (Production and Logistics) promulgate a policy requiring the Services and DLA to adopt a dynamic order quantity approach that will:

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- **Eliminate the current minimum 12-month order quantity floors.**
- **Use economic order quantity (EOQ) methods for developing order-quantity requirements, for formulating the stratification and budget, and for determining the order quantity for purchase requests.**
- **Override computed EOQs for the purchase request quantity only in specific cases for which past vendor data provides a realistic foundation for determining a more cost-effective price/quantity combination.**
- **Routinely solicit quantity discount ranges from vendors to provide opportunities for capturing price reductions.**
- **Adjust the buy quantity at the time of contract award on the basis of the quantity discount information available then.**
- **Develop information systems to allow the buyer to efficiently evaluate price/quantity alternatives in the award process.**

Supported by a series of technical recommendations designed to strengthen the visibility and control of computational parameters, this significant shift in OSD order quantity strategy represents the most feasible, most realistic alternative available to meet the competing priorities, pressures, and cost constraints that characterize today's inventory management environment. By jointly considering inventory investment and procurement workload, and by using the most current vendor price/quantity information available at the time of actual contract award, the approach recommended will substantially reduce current DoD order quantity requirements, will improve the flexibility of the system to respond to demand and other changes, and will minimize the risk of inapplicable assets.

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Executive Summary

DYNAMIC ORDER QUANTITY – AN ALTERNATIVE TO ECONOMIC ORDER QUANTITY

Overpricing by DoD vendors and the Competition in Contracting Act forced the Military Services and the Defense Logistics Agency (DLA) to re-examine their basic inventory management and procurement methods for spares and repair parts. To take advantage of price reductions associated with purchasing larger quantities and to offset growing procurement workload and administrative leadtimes, they increased their minimum order quantities from 3-months' supply to 12-months' supply.

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- Eliminate the current minimum 12-month order quantity floors.
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CHAPTER 1

INTRODUCTION

BACKGROUND

DoD Order Quantity Requirements

The Department of Defense (DoD) uses a continuous review, reorder point inventory replenishment system to manage spares and repair parts. The reorder point, composed of leadtime and safety levels, is used to alert the inventory manager that a replenishment order is required. The order quantity, in turn, indicates how much should be reordered.

Order quantities (often called operating levels or procurement cycle requirements) provide materiel to satisfy normal operating requirements between replenishment actions. The order quantity has been traditionally based on the economic tradeoffs between procurement workload (represented by the cost per order) and inventory investment (represented by the cost to hold the inventory). Under current DoD policy, the established order cost and holding-cost parameters and an estimate of demand for the item in question are used to compute an Economic Order Quantity (EOQ) – the quantity of materiel for which item annual order costs and annual holding costs are balanced to minimize total variable costs. This EOQ is then constrained to a minimum of 3 months of materiel and to a maximum of 3 years of materiel. Since 1984, DoD wholesale order quantity requirements for spares and repair parts have almost doubled. We have examined the policies and procedures used to determine these wholesale order quantity requirements to identify the sources of growth in these requirements and to evaluate the effectiveness of current order quantity methods.

DoD Pricing Deficiencies

During the early 1980s, DoD was severely criticized by Congress and the press for paying too much for spare parts procured from commercial suppliers. These so-called "overpricing" cases caused the Military Services and the Defense Logistics Agency (DLA) to re-examine the basic inventory control and procurement practices in use at the Inventory Control Points (ICPs). One major element of their review was the potential impact of the order quantity on the price paid, since larger order quantities offer the potential for lower prices from vendors based on economies of production. Because larger order quantities were shown to reduce the price in some specific cases, the Military Services and DLA began to incrementally increase minimum spares and repair parts order quantities as early as FY84 and by January 1985, the minimum wholesale order quantity being used for most "demand- and design-stable" spares and repair parts was 12 months of materiel. That "minimum 12-month order quantity" is a clear departure from established DoD policy, as outlined in DoD Instruction (DoDI) 4140.39, and for many items it represents a fourfold increase in the amount of materiel being ordered.

The Impact of CICA

On 1 April 1985, when the Competition in Contracting Act (CICA) became law, the environment in which spares and repair parts were procured at DoD ICPs changed dramatically. CICA imposed a significant number of new review and audit requirements, which, as a group, complicated and lengthened the procurement process at most ICPs. Among those new requirements were initiatives to "breakout" spares procurement to actual producers, to evaluate more carefully the prices charged based on value analysis, to increase the level of competitive procurement in order to pressure potential suppliers to provide the requested materiel at lowest price consistent with reasonable profits, and to purchase in more economic quantities. CICA caused many ICPs to further alter not only their procurement methods and policies but, in many cases, the basic organizational approach to the procurement process.

Today's ICP Processing Environment

Today's ICP environment is both complex and dynamic, with multiple processing steps across several functions, competing goals and priorities, significant cost-service tradeoffs, and time-sensitive processing volumes. The three primary factors that determine the overall efficiency of the ICP are inventory investment, obligation rates, and the degree or level of competition. Processing time, called administrative leadtime (ALT) and measured from the time a stock replenishment purchase request is generated until an order is placed, is the key linkage between the competing efficiency goals operable at the ICP.

Clear tradeoffs exist among the three efficiency factors. As order quantities increase, the number of purchase requests and, in most cases, the procurement workload and administrative leadtimes decrease. As a result, the ICP is able to increase obligation rates and devote more effort to increasing competition. The offsetting cost is a higher investment in inventory. In addition, the use of larger order quantities reduces the flexibility of the system to adjust to future demand and asset changes and places stresses on the forecasting system, typically reducing forecast accuracy. On the other hand, as order quantities decline and flexibility is improved, the number of purchase requests, workload, and administrative leadtimes increase. That decreases obligation rates and may affect competition.

In this ICP environment, strict application of EOQ methods to determine order quantities fails to adequately recognize the tradeoffs and competing objectives. Standard EOQ techniques do not permit the inventory manager to take advantage of quantity discounts available for larger order quantities. Moreover, the use of order cost as a surrogate for procurement workload fails to properly address the effect of replenishment workload volume on ALT, obligation rates, and safety-level investment. Thus, it is important that any review or analysis of DoD order quantity policy properly reflect and balance the varied and competing pressures and priorities common to the ICP.

Prior Studies

Since early 1985 when the minimum 12-month order quantity policy was implemented, DoD has undertaken a number of evaluations to determine its long-term net benefits. In addition to Service and DLA reviews, the DoD Inspector General and the General Accounting Office (GAO) have recently completed analyses of the economic impacts of the policy. As a group, these evaluations provide mixed results. Most conclude that the action to increase order quantities to a minimum 12-month "floor" is not cost-effective overall and suggest a return to the minimum 3-month policy. Other studies have recognized the benefits of the move to increase minimum order quantities primarily in terms of reduced procurement workload and the ability to buy at lower unit prices. To date, however, no analyses have attempted to reconcile the traditional EOQ approach and methodology with the operating environment of today's ICP and, based on those analyses, to propose policy changes allowing DoD to effectively deal with the mix of efficiency factors specified earlier.

SUMMARY FINDINGS

Growth in Order Quantity Requirements

DoD order quantity requirements reflected in Service/DLA stratification data indicate substantial growth between FY83 and FY87. Stratification data are limited to consumables and reparables for the Army and the Navy and, for the Air Force and DLA, to consumable items only. Working with opening position data on total demand-based replenishment stratification summaries of order quantity or procurement cycle requirements (PCR), we adjusted these stratification results as necessary in an effort to eliminate those replenishment requirements that were not a function of recurring demand forecasts. Thus, provisioning requirements, special program requirements, and other nondemand-based elements were largely excluded. The methodology employed varied by Service/DLA and is discussed in detail in Appendix B.

Based on these adjusted replenishment stratification reports, we computed the growth in order quantity requirements (see Table 1-1). The data shown include consumable spares and repair parts and reparables for the Army and Navy and consumable spares and repair parts for the Air Force and DLA. Aggregate DoD replenishment PCR increased from $4.7 billion in FY83 to $8.7 billion in FY87, an increase of $4.0 billion, or 86 percent, over the period. Adjusted for inflation and changes in demand over the period, Army PCR increased from 8.7 months of stock to 16.0 months of stock, Navy PCR increased from 8.9 months to 14.3 months, Air Force PCR from 6.6 months to 11.3 months, and DLA PCR decreased from 6.7 months to 6.0 months. However, if measured through FY86 (when DLA removed the minimum 12-month floor) DLA PCR increased to 9.0 months. As demand-based replenishment order quantity requirements increase because of longer procurement cycles, a series of other buy requirements are also added to the total PCR and therefore affect the total. These other requirements, including those represented by provisioning, program requirements, and other special requirements, when added to the replenishment order quantity requirements represent total PCR requirements that increased over the same period from $7.5 billion to $16.7 billion, or about 121 percent.

TABLE 1-1

GROWTH IN REPLENISHMENT PROCUREMENT CYCLE REQUIREMENTS

(Current dollars in thousands)

DoD Component	FY83	FY87	Percentage change	Change in dollar-weighted months[a]
Army	$ 965,821	$ 3,527,357	+ 265	+ 7.3
Navy	1,061,244	2,149,315	+ 103	+ 5.4
USAF	1,112,672	1,628,243	+ 46	+ 4.7
DLA	1,538,434	1,389,039	− 10	− 0.7
Total	$ 4,678,171	$ 8,693,954	+ 86	+ 5.4

Source: Service/DLA stratification data. March stratifications were used for Services; June for DLA. FY83 Navy data are from the 9/83 stratification.

[a] Dollar-weighted PCR months were computed by dividing the dollar value of the replenishment PCR by the dollar value of monthly demand.

Benefits of Larger Order Quantities

The benefits derived from larger order quantities include increased materiel availability and the ability to buy spares and repair parts in quantities that would allow price reductions by vendors to reflect production economies. Price reduction of 5 to 15 percent and more have been documented for selected items for which order quantities have been increased above normally computed levels. In addition, increases in order quantities reduce the number of procurement requests for stock replenishment actions. For the ICPs included in our analysis, we observed a replenishment procurement workload reduction of approximately 20 percent over the period FY83 through FY87. These benefits are tangible and real and must be recognized in any order quantity policy. Unfortunately, the total benefit of larger order quantities is obscured by several factors. First, stock replenishment workload is only one element of total procurement workload at most ICPs. Procurement of provisioning and other special requirements, procurement of materiel for delivery directly to end-users, and procurement of materiel and services for base support and operations may represent a significant portion of total procurement workload at a given ICP, and the workload measurement systems reviewed do not uniformly segregate those disparate elements.

Second, even where stock replenishment workload could be separated and analyzed, it is not always evident how the size of the order quantity affects this workload. Even though the number of stock replenishment purchase requests going to procurement may be reduced (by larger order quantities), the actual procurement workload associated with processing these purchase requests (measured in labor hours) may increase because purchase requests previously processed under small purchase procedures must now be processed under more time-consuming large purchase procedures.

Third, while larger order quantities increase the potential for price reductions, those price reductions may not exist for every item. Further, the price reductions that are realized may be too small to be cost-effective or may not be the result of the increase in the order quantity. Finally, while additional on-hand inventory assets generally improve material support, the same dollar investment may have a greater impact on material availability if safety level stocks are augmented. Thus, although we recognize the conceptual benefits of larger order quantities, our ability to quantify the total benefits associated with larger wholesale secondary item order quantities is limited.

Costs of Larger Order Quantities

The costs to DoD of larger order quantities fall in three separate but related areas. First, larger order quantities directly increase on-hand inventory investment which results in increased holding costs. As reflected in Table 1-2, we estimate that for the roughly $4 billion increase in replenishment PCR requirements over the period FY83 to FY87, additional annual holding costs incurred by the DoD are approximately $300 million. If we consider the growth in total PCR requirements, increased annual holding costs approximate $670 million.

Second, because larger order quantities extend the demand forecasting horizon, the accuracy of demand forecasts used to compute the actual buy quantity is reduced and the assumption of steady demand becomes highly questionable. This problem is particularly relevant given the demonstrated demand variation common in DoD even for so-called "stable" demand items. A sample of these items, used in an earlier DoD Inspector General (IG) review of order quantity policy, was reassessed in this

TABLE 1-2

GROWTH IN REPLENISHMENT PROCUREMENT CYCLE REQUIREMENTS

DoD component	Dollar value of one replenishment PCR month ($000)	Growth in dollar-weighted replenishment PCR (months)	Dollar value of replenishment PCR growth ($000)
Army	$ 220,104	+ 7.37	$ 1,622,737
Navy	150,652	+ 5.35	806,330
USAF	143,946	+ 4.75	683,604
DLA	228,761	+ 3.81	872,213
Total	$ 743,463	+ 5.36	$ 3,984,884

Source: Service/DLA stratification data.

Notes: DLA PCR value from FY86; DLA PCR growth from FY83 to FY86 because 12-month floor was removed in July 86. Service PCR values from FY87; PCR growth from FY83 to FY87.

study. All sample items were consumables whose computed EOQ was less than 1 year and, as reflected in Figure 1-1, in a sample of 789 items specifically identified as stable-demand items by the Services and DLA, actual demand changes over a 12-month period are striking. As shown, over 40 percent of these "stable-demand" items experienced demand changes ±40 percent or more over the 15-month period.

Finally, the combination of larger order quantities and volatile demand clearly increases the likelihood of having inapplicable assets on-hand or on-order above the established Approved Force Acquisition Objective (AFAO) because it reduces the flexibility of the inventory manager to react to unanticipated demand changes and to changes in other factors that determine requirements. As shown in Table 1-3, the percentage growth in both on-hand and on-order inapplicable assets for a sample of 789 stable-demand items whose computed order quantity had been increased to a minimum of 12-months of material is significantly larger than for the DoD stratified spares and repair parts inventory as a whole. While our total stratified base of consumables and reparables reflected an average growth rate of 17 percent a year for inapplicable on-hand assets and 38 percent a year for inapplicable on-order assets,

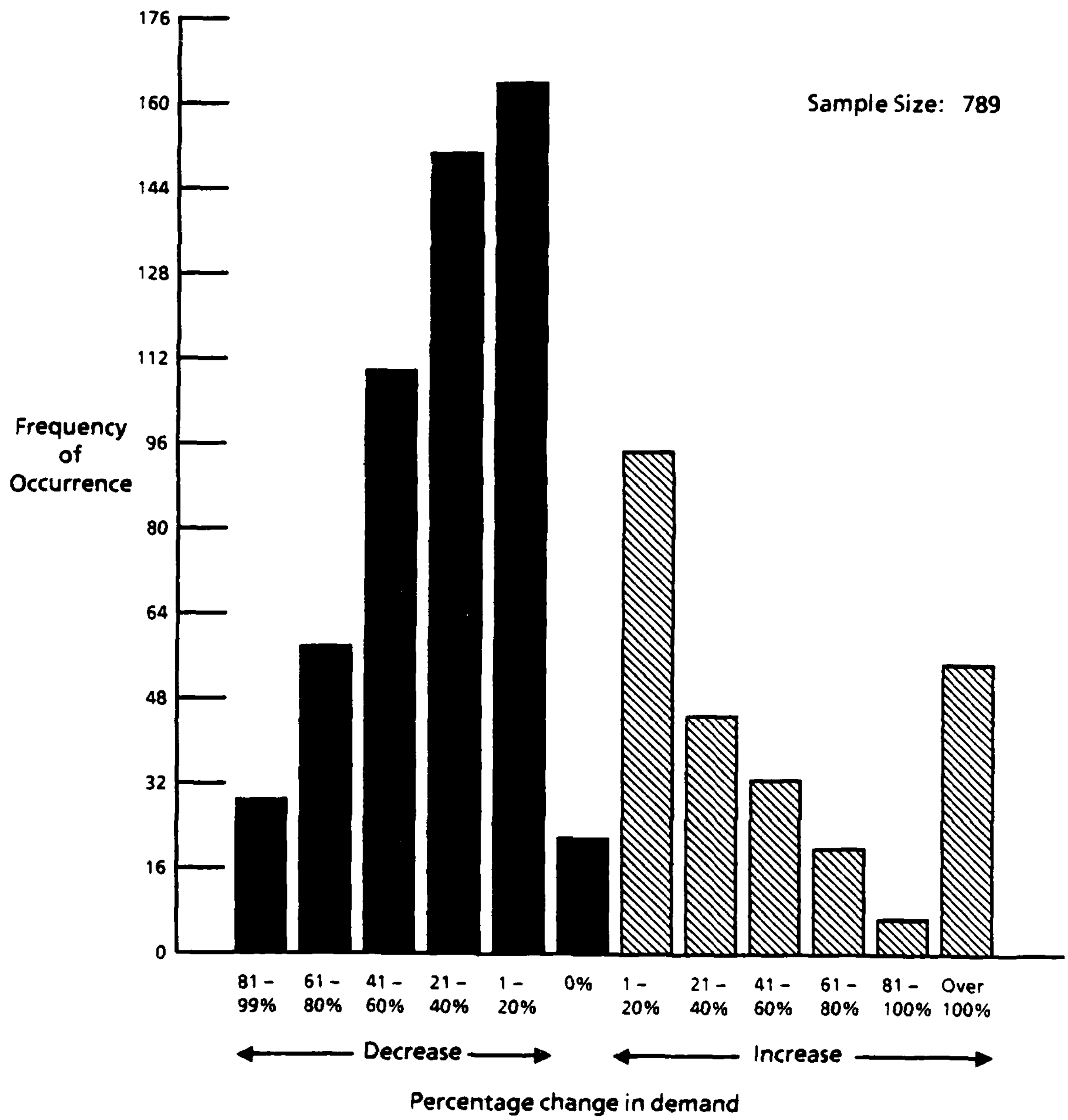


FIG. 1-1. CHANGE IN STABLE-DEMAND SAMPLE

inapplicable on-hand assets increased 243 percent in 1 year and inapplicable on-order assets increased 40 percent in 1 year in the sample database.

TABLE 1-3

GROWTH IN INAPPLICABLE ON-HAND AND ON-ORDER INVENTORY
(Current dollars in millions)

Inventory	Overall DoD stratification data			789-item sample		
	1984	1987	Average % change per year	1986	1987	Average % change per year
Inapplicable on-hand	$6,246.9	$9,488.0	+ 17	$2.3	$7.9	+ 243
Total on-hand	$19,735.1	$27,717.1	+ 13	$55.8	$76.1	+ 36
% inapplicable	32%	34%	–	4%	10%	–
Inapplicable on-order	$884.3	$1,833.4	+ 35	$7.0	$9.8	+ 40
Total on-order	$12,745.9	$19,003.1	+ 16	$134.9	$158.8	+ 18
% inapplicable	7%	10%	–	5%	6%	–

Source: Service/DLA stratification and line item sample data.

Procurement Workload Impacts

The net effect of larger minimum order quantities on procurement workload is not clear because many factors changed during the period, including processing requirements, buying methods, and the mix of total workload flowing through the procurement activity. Hence, procurement workload should not be used as a constraint in the computation of order quantity levels. However, many of the ICPs surveyed have been extremely successful in reducing workload through innovative, multiyear procurement methods. By far the most successful technique being used is the routine solicitation of multiple quantities based either on the order quantity requested in the purchase request or on quantity ranges. By eliciting quantity discount alternatives specific to a line item, the ICP is able to exploit quantity discount alternatives where appropriate to minimize total cost to the Government, and many ICPs have implemented valid and auditable evaluation models to mechanize and standardize the process of evaluating these alternative price-quantity combinations. Other multiyear buying methods, such as indefinite-type contracts and requirements contracts are also being used on a more restricted basis with success at some ICPs surveyed.

SUMMARY CONCLUSIONS

Based on the major findings of the study, we draw the following conclusions:

- While some changes have been made in the order cost and holding cost parameters used to compute EOQs, the primary factor in the substantial growth in DoD order quantity requirements over the past 5 years has been the implementation of larger minimum order quantity floors by the Military Services and DLA.

- In implementing larger minimum order quantities, the Military Services and DLA failed to properly recognize the extreme demand variance – often a 20 or 30 percent change over a 12-month period – that exists even for so-called stable-demand items. This extreme demand volatility adversely affects the ability of the system to accurately forecast demand for use in requirements determination and is clearly at odds with the assumption of demand stability, which is the foundation upon which the use of larger minimum order quantities is based.

- The combination of larger minimum order quantities and demonstrated demand variability has resulted in a substantive increase in inapplicable assets on-hand and on-order. Smaller order quantities would provide flexibility by allowing the inventory manager to react more effectively to demand changes over time, and increasing minimum order quantities significantly reduces that flexibility.

- Further, ICP procurement workload is highly susceptible to changing requirements and is composed of several major elements (including initial provisioning buys, special program buys, end-use or direct turnover buys, base/administrative support buys, and stock replenishment buys). Each of these procurement workload elements is difficult to forecast. While stock replenishment procurement workload has been reduced through larger minimum order quantities, its effect on total procurement workload is not clear.

- Opportunities for quantity discounts on a wide range of items do exist, and active solicitation of quantity alternatives (ranges or multiples of the purchase request quantity) generate tangible results for selected items. In addition, other selective or tailored procurement techniques also appear highly beneficial for selected inventory segments and markets. These methods, which typically extend to a multiyear contract period, include several forms of Indefinite-Delivery Contracts (IDCs).

- Finally, strict application of EOQ principles in determining the order quantity fails to properly compensate for existing workload constraints at the ICPs and does not adequately recognize the possibility of quantity discounts on selected items. The initial EOQ is not necessarily an economic *buy* quantity since the full range of information necessary to determine lowest total cost to the Government is available to the ICP only at the time of contract award. As a result, the order quantity decision should be separated from the *buy* quantity decision to manage the entire process in a cost-effective manner.

SUMMARY RECOMMENDATIONS

Considered in total, our conclusions point to a major strategic change in the current OSD wholesale spares and repair parts order quantity policy. That strategic shift, which will require systems changes and revised processing rules, essentially recognizes that it is only at the time of contract award that the ICP has the necessary information (on alternative prices and quantities, current demand and assets, etc.) to make an effective order quantity decision. Specifically, we recommend that the Assistant Secretary of Defense (Production and Logistics) [ASD(P&L)] establish the following policy for DLA and the Services:

- Discontinue the use of the minimum 12-month order quantity floor and reconfirm the use of EOQ methods for development of stratification and budget requirements and for generating a target order quantity for purchase request purposes. Constrain this computed EOQ to a maximum quantity of 36 months of material and to a minimum quantity equal to the item's administrative leadtime (in units).

- Routinely solicit quantity discount ranges (as multiples of the purchase request quantity) in spares and repair parts solicitations to create opportunities for vendor price reductions and to provide the inventory managers with the flexibility to adjust to demand and asset changes during the ALT.

- Develop an appropriate budgeting methodology to provide funding needed to support valid quantity discount buys beyond the current year requirement.

- Further expand the use of other tailored, multiyear purchasing methods such as IDCs and requirements contracts on a selective basis to reduce procurement workload, realize price advantages, and minimize inventory investment.

- Determine the actual buy quantity at the time of contract award using the quantity discount information (and other relevant data such as current demand/asset data) by adjusting the purchase request target order quantity based on total cost to the Government.

- Develop the necessary information-processing systems capabilities to allow the implementation of the dynamic order quantity policy by incorporating current off-line evaluation models as a part of standard ICP processing and by appropriately recognizing in stratification the resulting orders placed.

REPORT FORMAT

The remaining sections of this report provide more detail and analytical support for the general results summarized here. In Chapter 2 we present the specific findings of the study. Chapter 3, in turn, develops the conclusions and formulates related recommendations in a form useful to OSD. Technical recommendations for revision of DoDI 4140.39 are isolated and highlighted, and recommendations for program or system changes are outlined. Finally, we present the detailed analyses on which study results are based in a series of appendices. Appendix A discusses the scope and methodology of the study in depth. It is followed, in Appendices B and C, by our analysis of order quantity requirements and inapplicable assets on-hand and on-order. There, we present more specific details in support of our findings and conclusions. Appendix D presents results of our review of the Federal Acquisition Regulation (FAR) provision that ICPs must solicit so-called Economic Purchase Quantities (EPQs) from vendors. ICP compliance and vendor reaction to that specific FAR clause are documented. Finally, Appendix E provides analysis of order quantity parameters and a series of computational and technical changes designed for incorporation in the current DoDI 4140.39.

CHAPTER 2

FINDINGS

This chapter presents the major findings of the study organized on the basis of the impact of order quantity changes on three primary factors:

- Total procurement cycle requirements
- Inapplicable on-hand and on-order assets
- Procurement workload and buying methods.

IMPACT OF CHANGES IN DoD ORDER QUANTITY ON TOTAL PROCUREMENT CYCLE REQUIREMENTS

Findings

Changes in PCR

Replenishment stratification reports were adjusted (see Appendix B) to focus on the demand-based portion of the total PCR by excluding new items still within their demand-development period, other special or program-related requirements, and nondemand-based or insurance items. Thus, the pure effect of changes in the order quantity algorithms, parameters, or constraints are most accurately seen from analysis of replenishment stratification reports. We further constrained our stratification coverage to include only consumable items for the Air Force. In Table 2-1, we show the absolute growth in these replenishment PCR – an aggregate increase of about $4 billion, or 86 percent, from FY83 to FY87. Figure 2-1 illustrates the relative, or percentage, growth of replenishment PCR by Military Service and DLA during the same period. It shows that the Army (265 percent), Navy (103 percent), and Air Force (46 percent) all experienced substantial growth. For DLA the increase in replenishment PCR (34 percent) was also extensive until DLA removed the minimum 12-month floor in June 1986. This marked growth in replenishment PCR on a consistent and continuing basis is, in large part, a function of the 12-month minimum order quantity constraint that was implemented on a broadening base of items over the FY83 to FY85 timeframe.

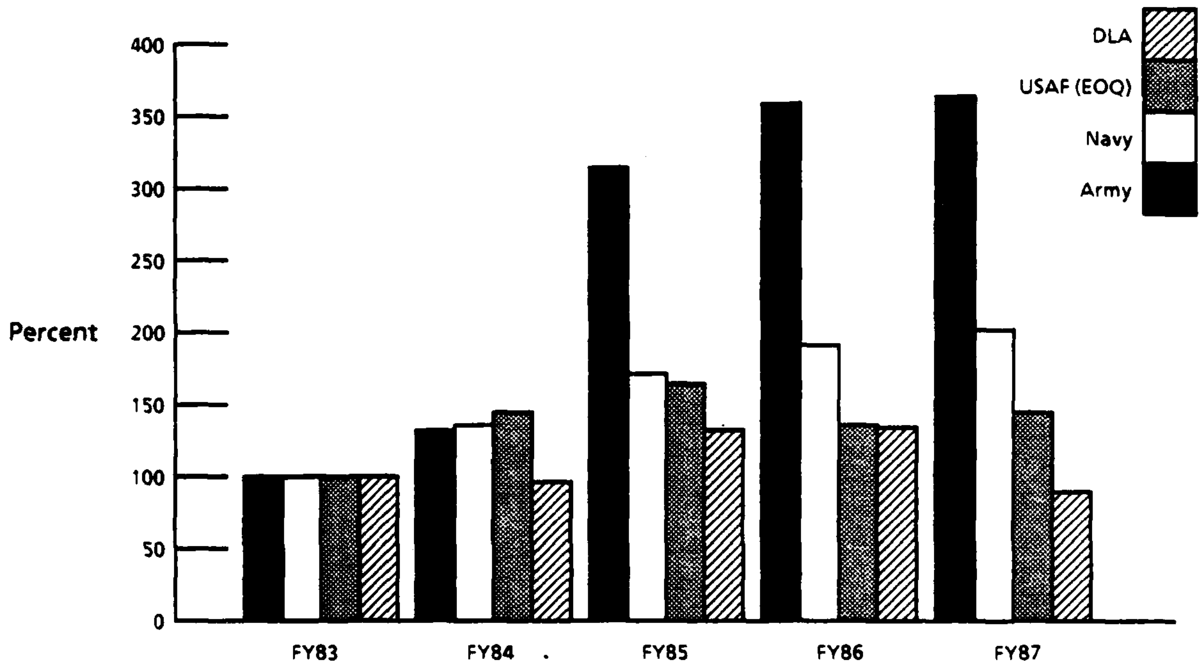
TABLE 2-1

GROWTH IN REPLENISHMENT PROCUREMENT CYCLE REQUIREMENTS

(Current dollars in thousands)

DoD Component	FY83	FY84	FY85	FY86	FY87
Army	$ 965,821	$ 1,286,676	$ 3,037,554	$ 3,467,796	$ 3,527,357
Navy	1,061,244	1,453,373	1,833,207	2,034,842	2,149,315
USAF	1,112,672	1,620,519	1,838,485	1,510,672	1,628,243
DLA	1,538,434	1,487,901	2,040,331	2,066,359	1,389,039
Total	$ 4,678,171	$ 5,848,469	$ 8,749,577	$ 9,079,669	$ 8,693,954

Source: Service/DLA stratification data. March stratifications are used for Services; June for DLA. FY83 Navy data are from the 9/83 stratification.



Source: Service/DLA stratification data.

FIG. 2-1. REPLENISHMENT PCR GROWTH SINCE FY83

However, not only did this larger minimum order quantity constraint directly affect DoD replenishment PCR, it also increased other order requirements because the replenishment PCR horizon is also used by the Services and DLA to "pull in" provisioning, nondemand-based, and special or program requirements for procurement. As a result, opening position summary stratification reports show that the total DoD PCR increased from $7.6 billion in FY83 to $16.7 billion in FY87 as shown in Table 2-2. On a percentage basis, as shown in Figure 2-2, the *relative* growth of total PCRs, during the past 5 fiscal years ranges from a 30 percent increase for DLA to 175 percent for the Army.

TABLE 2-2

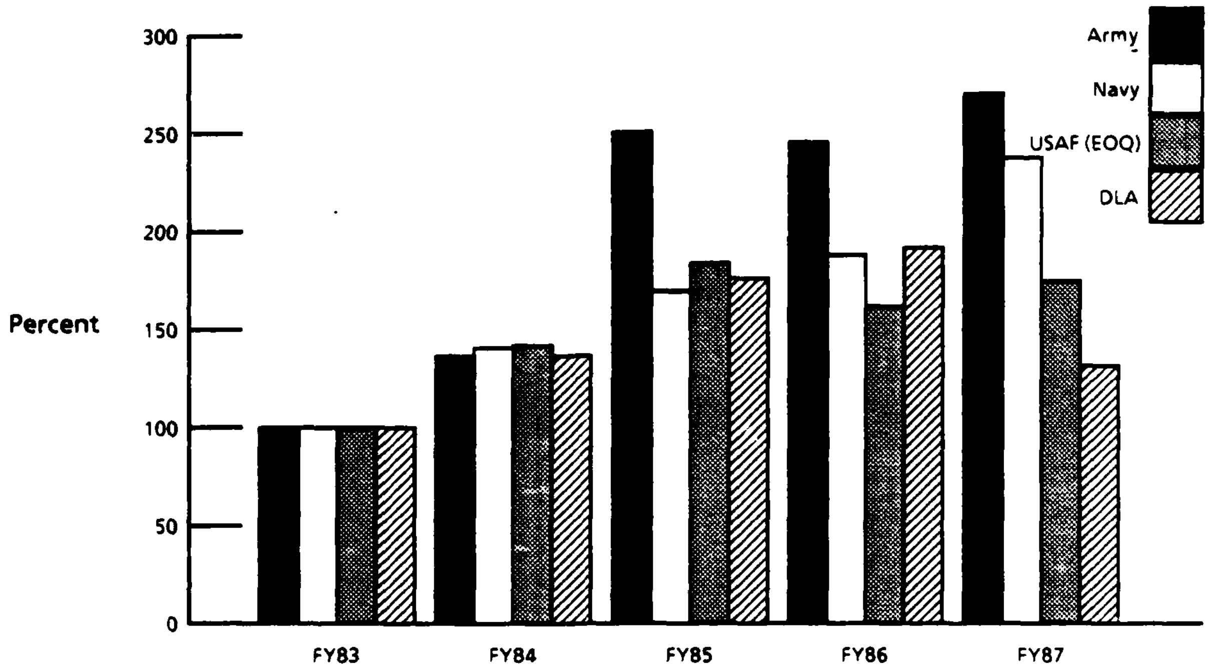
GROWTH IN TOTAL PROCUREMENT CYCLE REQUIREMENTS
(Current dollars in thousands)

DoD Component	FY83	FY84	FY85	FY86	FY87
Army	$ 2,186,947	$ 2,994,881	$ 5,502,022	$ 5,391,132	$ 5,956,404
Navy	2,867,191	4,073,308	4,879,928	5,426,818	6,838,932
USAF	1,339,168	1,916,138	2,475,165	2,175,709	2,360,004
DLA	1,157,138	1,596,709	2,052,081	2,236,911	1,531,525
Total	$ 7,550,444	$ 10,581,036	$ 14,909,196	$ 15,230,570	$ 16,686,865

Source: Service/DLA stratification data. March stratifications were used for the Services; June for DLA. FY83 Navy data are from the 9/83 stratification.

Changes in Order Quantity Algorithms

The computational approaches used by the Services and DLA for wholesale secondary item order quantities are based on the concept of the Wilson EOQ. As explained in Appendix E, the objective of the Wilson EOQ is to minimize the sum of the variable holding and order costs. Changes in those computational methods could affect PCR over time; however, the algorithms employed in DoD to compute order quantities have not changed significantly for many years. That stability is in sharp contrast to the dynamic changes in the other two areas that have a major potential impact on order quantities: the parameters used in the algorithms and the constraints imposed on the results of the calculations.



Source: Service/DLA stratification data.

FIG. 2-2. TOTAL PCR AS PERCENT OF FY83 TOTAL PCR

Changes in Computational Parameters

The Wilson EOQ uses the following computational parameters: item unit price, forecast demand, dollar cost to place an order, and an annualized holding cost rate. Unit price and forecast demand are extracted from the item inventory record; order costs and holding cost rates are provided exogenously. Appendix E provides more specific discussion.

An examination of the various ICPs shows that they use an inconsistent range of values for order and holding costs. Further, some values are consistently updated, while others are outdated. Each Service has changed the values used in order-quantity calculations in recent years, and virtually all of those changes have increased computed economic order quantities. That is, when order costs have been changed, they have been increased and when holding costs have been changed, they have been reduced. By contrast, DLA has not changed its order-quantity parameters for many years. Currently, no system provides regular visibility of these values, changes to the values, or methods used to establish them to officials responsible for reviewing stratification reports and spares and repair parts budget requests. The current values of holding-cost rate and order costs, the changes made by the Services, and system deficiencies are discussed in Appendix E.

Changes in Minimum Order Quantity Constraints

Beginning in 1984, the Ser ices and DLA implemented a 12-month minimum constraint on spares and repair parts order quantities for demand- and design-stable items to achieve lower unit prices and to reduce procurement workload. While the Services and DLA implemented the minimum order quantity constraint at different times, the change was a clear departure from the official DoD policy on computed order quantities – a 3-month minimum and a 36-month maximum – as reflected in DoDI 4140.39. The Air Force changed to a 12-month minimum in early FY84; the Army approximately 6 months later; and the Navy over approximately 2 years ending in June 1985 (when it was in force for most stable demand items). DLA implemented the 12-month minimum constraint for selective items in 1985 and canceled it in July 1987. The Military Services have continued to employ the 12-month floor and, in some cases, have further increased its length.

Summary

The substantial growth in PCR since FY83 is primarily the result of two factors: implementation of the 12-month minimum order quantity and selective changes to the values of the parameters used to compute order quantities. While the minimum 12-month order quantity was conceptually appealing to the ICPs and could be shown to reduce unit prices for selected items, its potential effect on total inventory requirements when applied to a broad range of spares and repair parts was not properly recognized. We found no Service or DLA analysis of the minimum order quantity change that provided any comprehensive justification for the shift. Only after facing the dramatic increases in order-quantity requirements that have occurred since FY83, the significant growth in inapplicable assets, and the reduced funding levels experienced in the past year have some ICPs begun to reconsider the reasonableness of the decision. In addition to the significant increase in the minimum order quantity constraint, order-cost and holding-cost rate values have also been selectively adjusted and the net result of those changes has been to increase computed order quantities. Substantive differences in these values that now exist both within and across the Services and DLA are difficult to reconcile, and neither the Service Headquarters nor OSD has visibility of, and appreciation for, the effect of these value changes.

GROWTH IN INAPPLICABLE ON-HAND AND ON-ORDER ASSETS

Inapplicable Asset Analysis

Inapplicable assets are defined here as assets in excess of the Approved Force Acquisition Objective (AFAO) – the quantity of an item authorized to equip and sustain U.S. Approved Forces in peacetime and in wartime. We studied the effect of the changes in order quantities on inapplicable assets in two ways. First, we established the aggregate trends in inapplicable assets based on Service/DLA stratification summaries. Both consumable and reparable items were included for the Army and the Navy; however, Air Force and DLA stratification data were limited to consumable items only. Second, we analyzed line-item data for 789 consumable line items that had order quantities increased by a 12-month minimum constraint floor on order quantity so that we could determine the major factors that appeared to be related to inapplicable assets.

Macro Findings

Viewed in the aggregate, inapplicable on-hand and on-order assets have grown steadily over the past several years. From FY84 to FY87, inapplicable on-hand assets increased from $6.247 billion to $9.488 billion (an increase of more than 50 percent), while inapplicable on-order assets grew more than 100 percent, from $0.88 billion to $1.83 billion in FY87.

As summarized in Tables 2-3 and 2-4, a portion of that growth in inapplicable assets reflects general increases in the overall asset base of DoD. However, as indicated in the tables, inapplicable assets as a percentage of total assets have also increased for each DoD Component. The percentage of inapplicable on-hand assets to total on-hand assets now ranges from about 27 percent for Army to roughly 48 percent for Air Force, while inapplicable on-order assets as a percentage of total on-order assets ranges from 8 percent for Army to 12 percent for Air Force.

TABLE 2-3

INAPPLICABLE ON-HAND ASSET GROWTH

(Current dollars in millions)

DoD Component	FY84	FY85	FY86	FY87
Army	$1,090 (25%)	$1,408 (27%)	$1,727 (29%)	$1,876 (27%)
Navy	$2,715 (34%)	$2,861 (32%)	$3,291 (30%)	$4,270 (35%)
Air Force	$1,668 (43%)	$1,665 (45%)	$1,464 (46%)	$2,055 (48%)
DLA	$775 (23%)	$685 (20%)	$1,027 (26%)	$1,287 (28%)
Total	$6,248 (32%)	$6,619 (31%)	$7,509 (31%)	$9,488 (34%)

Source: Service/DLA stratification data.

Note: ( ) = percent of total on-hand assets.

Micro Findings

Line-Item Sample

In order to identify the potential sources of inapplicable asset growth observed at the aggregate level and to evaluate the specific impact of increased order quantities, we used an item-specific sample of consumable items drawn in March 1986 and updated again in July 1987. That sample is composed of 789 stable-demand items that were included in Service and DLA annual buy programs and that had normally computed order quantities of less than 12 months.

A comparison of our item sample to the total DoD consumable item population from which it was drawn shows that the percentage of inapplicable assets on hand (10 percent) and on order (6 percent) in the sample is smaller than that on hand (34 percent) and on order (10 percent) for the FY87 stratification data as a whole. That difference is not surprising since our sample consists of "steady-demand, fast-moving" items that generally receive more intensive management by the wholesale inventory manager. However, the annual rate of growth in inapplicable assets

TABLE 2-4

INAPPLICABLE ON-ORDER ASSET GROWTH

(Current dollars in millions)

DoD Component	FY84	FY85	FY86	FY87
Army	$179 (5%)	$308 (6%)	$761 (13%)	$587 (8%)
Navy	$506 (10%)	$915 (13%)	$1,163 (14%)	$750 (10%)
Air Force	$87 (4%)	$175 (8%)	$190 (10%)	$278 (12%)
DLA	$113 (7%)	$106 (6%)	$258 (12%)	$219 (11%)
Total	$885 (7%)	$1,504 (9%)	$2,372 (13%)	$1,834 (10%)

Source: Service/DLA stratification data.

Note: ( ) = percent of total on- order assets.

on-hand (243 percent) and on order (40 percent) in the sample is substantially greater than the average percentage growth per year in inapplicable on-hand (17 percent) and on-order (35 percent) assets in the stratification population between FY86 and FY87.

Growth in Inapplicable Assets

In the line-item sample, inapplicable assets increased considerably between the two sample periods, as indicated in Table 2-5. Measured in constant dollars to eliminate price impacts, inapplicable on-hand assets increased from $2.9 million (40 items) to $7.9 million (114 items), while inapplicable on-order assets increased from $8.5 million (77 items) to $9.8 million (120 items). Over a period of approximately 15 months, the inventory posture of these so-called "stable-demand" items, where computed order quantities were increased roughly fourfold to a minimum of 12 months, deteriorated substantially as the dollar value of inapplicable on-hand assets increased by 175 percent and the dollar value of on-order assets increased by 14 percent.

TABLE 2-5

GROWTH INAPPLICABLE ON HAND AND ON ORDER

(Number of cases)

DoD component	Items with on-hand inapplicable		Items with on-order inapplicable	
	Sample 1 (3/86)	Sample 2 (6/87)	Sample 1 (3/86)	Sample 2 (6/87)
Army (n = 98)	2	5	16	19
Air Force (n = 208)	16	41	25	38
Navy (n = 210)	20	33	33	33
DLA (n = 273)	2	33	3	30
Totals				
Items	40	114 (+ 185%)	77	120 (+ 56%)
Dollars[a]	$2,884.3	$7,921.5 (+ 175%)	$8,542.4	$9,772.9 (+ 14%)

Source: Service/DLA line-item sample data.

[a] Constant dollars in thousands.

Changes in Demand

The dramatic growth in inapplicable assets in our item sample took place over a period of approximately 15 months. During that period, aggregate annual demand dollar value for those items remained fairly stable – $62.8 million in 1986 and $60.8 million in 1987. However, an analysis of individual line items, presented in Table 2-6, shows that individual item demand varied considerably, that over 97 percent of the items had some change in demand, and that almost two-thirds of the sample items experienced demand changes greater than 20 percent. For the 512 items with demand declines, two-fifths had demand declines greater than 40 percent.

The Impact of Demand Change and Order Quantity on Inapplicable Assets

Demand changes, coupled with the sizable increase in order quantity, had a strong statistical relationship to the incidence, magnitude, and growth of

TABLE 2-6

DEMAND CHANGE IN ITEM SAMPLE

Sample size = 789

Items	Demand change (percent decrease)					No change	Demand change (percent increase)					
	81 to 99	61 to 80	41 to 60	21 to 40	0 to 20		0 to 20	21 to 40	41 to 60	61 to 80	81 to 100	Over 100
Number	29	58	110	151	164	22	95	45	33	20	7	55
Total	512 (64.9%)					22 (2.8%)	255 (32.3%)					

Source: Service/DLA line-item sample data.

inapplicable assets as shown by multivariate regression analysis of the sample data. The regression analysis focused on three aspects of inapplicable assets: (1) incidence or likelihood of inapplicable assets, (2) the magnitude of inapplicable assets when they do occur, and (3) the growth of inapplicable assets. For this analysis, we measured both the degree to which on-hand and on-order assets exceeded the Requirements Objective (RO) and the degree to which they were technically inapplicable (i.e., above the AFAO). A detailed description of this regression analysis is included in Appendix C.

In each of the regression runs, a consistent group of independent variables emerged as statistically significant. The number of new cases of inapplicable assets, both on hand and on order, occurred most often for those items whose demand had decreased. Of 90 new cases of on-hand inapplicable assets, 86 occurred in items with a demand decline, and of 101 new cases of on-order inapplicable assets, 90 occurred in items with a demand decline. Moreover, as shown in Table 2-7, the most important factors statistically related to the likelihood, size, or growth in inapplicable assets were the percentage change in demand and changes in the elements that make up the material requirement, including the size and percentage change in EOQ, the size of the safety level (SL), and the size of the procurement leadtime level (LT). While the relatively low R^2 value in most of the regression results suggests that these variables alone are not a strong predictor of the relationship to inapplicable assets, the overall estimating equations provide a statistically significant estimate at the 95 percent confidence level (based on the computed F-statistic) as indicated.

TABLE 2-7

PREDICTING THE INCIDENCE, MAGNITUDE, AND GROWTH OF INAPPLICABLE ASSETS

Sample Items

Dependent variable	R^2 value	Independent variables and coefficients			
		Demand	EOQ	SL	LT
Likelihood of inapplicable assets					
On hand >AFAO	0.055[b]	- 0.089[a]	0.017[a]	0.004[a]	0.002[a]
On order >AFAO	0.061[b]	- 0.076[a]	0.025[a]	0.008[a]	0.003[a]
Magnitude of inapplicable assets					
On hand >AFAO	0.399[b]	- 11.428[a]	84.906[a]	8.034[a]	4.629[a]
On order >AFAO	0.113[b]	- 190.321[a]	30.810	9.619[a]	- 3.354
Growth of inapplicable assets					
On hand >AFAO	0.426[b]	- 11.907[a]	- 4.720	- 0.031	- 0.554
On order >AFAO	0.046	- 39.510	- 14.680	- 1.759	1.286

Source: Service/DLA line-item sample data.

[a] Statistically significant at the 95 percent confidence level.

[b] All results are statistically significant at the 95 percent confidence level based on the computed F-statistic.

Summary

Results of the macro and micro analyses of inapplicable assets are consistent. On a macro level, inapplicable on-hand assets have increased by over $3 billion and inapplicable on-order assets have increased by about $1 billion since FY84. That growth represents not only dollar resources committed unnecessarily but also increased annual holding costs of $450 million. Further, the fact that inapplicable assets are growing at a rate faster than that of total on-hand and on-order assets suggests that the level of inapplicable assets will continue to grow unless positive measures are taken to reverse the trend.

We conclude that at the micro level, demand variation had a significant impact on the occurrence and quantity of inapplicable assets in our sample. Most of the new cases of inapplicable assets occurred when demand declined, and the greater the demand decline, the greater the incidence, magnitude, and growth of inapplicable assets. Further, we conclude that the size and the percentage growth of the order quantity are also significant factors in the incidence, magnitude, and growth of inapplicable assets. Larger order quantity requirements, coupled with the relative instability of DoD demand, clearly increase the risk of inapplicable assets. The statistical results derived in the regression analysis are strongest when considering on-hand assets above the AFAO. The strength of the statistical estimates is not as substantial when inapplicable on-order assets are analyzed because such assets are terminated or received (and added to inapplicable on-hand assets) so that the level of inapplicable on-order assets is extremely dynamic over time.

PROCUREMENT WORKLOAD AND BUYING METHODS

Findings

Workload Impacts

Among the benefits of the minimum 12-month order quantity floor is an overall reduction in the number of procurement actions. Workload data indicate that the total number of purchase requests processed at the ICPs in our survey has declined by approximately 20 percent over the past 4 years, as shown in Table 2-8. However, because we could not isolate other changes unrelated to replenishment item order quantity during that same time period (such as increases in program demand, continuing changes in procurement procedures and contracting methods, and changes in item-management responsibilities), we could not determine the extent to which this reduction was a direct function of reduced order quantities.

Buying Methods

All of the ICPs surveyed are seeking ways to make quantity-price tradeoff decisions based on economic analysis and to reduce workload and its effect on ALT

TABLE 2-8

IMPACT OF 12-MONTH ORDER QUANTITY
ON PROCURMENT WORKLOAD

(PRs in thousands per FY)

DoD Component	PRs before 12-month minimum	PRs after 12-month minimum	PRs saved	Percentage change
Army	61.1	48.7	12.4	-20
Air Force	49.1	31.6	17.5	-35
Navy	131.8	115.6	16.2	-12
DLA	815.3	647.3	168.0	-20
Total	1,057.3	843.2	214.1	-20

Source: Service/DLA ICP survey data.

through changes in buying methods. The following innovative contracting methods are being used with mixed success at different ICPs:

- Range bidding
- Stepladder/quantity discounts
- EPQ solicitation
- Contract options
- Multiple-year buys
- Indefinite delivery/requirements contracts
- Priced basic ordering agreements (BOAs).

One of the most widespread and successful procurement approaches for addressing the price-quantity issue is the use of range bidding and stepladder or quantity discount solicitations. In range bidding, procurement solicits the requirement using a range of bid quantities, both above and below the original requirement quantity. Stepladder or quantity discount solicitations are similar to range bidding except that specific alternative quantities are solicited. Both methods successfully generate quantity discounts for different order quantities, and those discounts can be evaluated to determine an optimal (low cost to the Government) quantity. Moreover, in both cases, the inventory manager may be given an opportunity to review the requirement before the award is made and adjust the quantity purchased based on the most current inventory information. With current ALTs ranging from 6 months to more than a year, this approach allows for the most current information to be used in making the procurement decision, mitigating at least some of the negative effects of the extended ALT.

A second approach designed to deal with price/quantity relationships is solicitation of EPQ data from vendors. The EPQ is the quantity at which the vendor realizes cost economies that can be passed on to the Government in the form of lower unit prices. The requirement to gather price-quantity data in the solicitation is now imposed by the FAR but has largely been ineffective. As shown in Table 2-9, the vendor response to this inquiry has been negligible.

TABLE 2-9

ECONOMIC PURCHASE QUANTITY IMPACTS

DoD Component	Implementation period	Percentage of solicitations w/FAR clause	Vendor response rate (%)
Army	11/85 – 12/86	79	6
Air Force	11/85	100	6
Navy	4/86 – 1/87	100	6
DLA	9/85 – 1/86	98	3

Source: Service/DLA ICP survey data.

A third general category of procurement methods is primarily geared to reducing the frequency with which a given item is ordered and thereby decreasing procurement workload. It includes the use of contract options, multiple-year buys, indefinite delivery/requirements contracts, and priced BOAs. Those alternative methods are being successfully applied on a selective basis and have the potential to lower unit cost and reduce procurement workload. In each alternative, requirements are projected for a period beyond the immediate requirement and the solicitation is made for a larger quantity. Deliveries are then scheduled on a periodic or "as-needed" basis, thereby eliminating increases in average inventory and avoiding the inaccuracy associated with projecting requirements through a lengthy procurement leadtime. ICPs report mixed success and varying vendor acceptance.

Evaluation Models

In view of the many procurement solicitation methods discussed above, ICPs must often choose among several price-quantity responses at the time of award. Usually, those responses are submitted for solicitations that explicitly ask for prices for different quantities. The Air Force, Navy, and DLA have developed computer models to help buyers and inventory managers assess the responses. Frequently vendors will offer lower unit prices for larger purchase quantities, which reduces both the annual cost of material and the annual ordering costs but increases annual holding costs. The tradeoff models attempt to quantify the *total* annual costs of each alternative.

Price-quantity tradeoff models currently in use are computationally sound, provide the necessary audit trail to respond to potential vendor challenges, and are operationally viable based on current workload volume. However, those tradeoff models have not been incorporated into the basic inventory control procurement information systems. They operate as stand-alone systems, their output is hard copy, and the communications between procurement and inventory control regarding price/quantity options increases ALT. Furthermore, when an order quantity that is larger than the purchase request quantity is exercised by the buyer, today's ICP systems are often unable to effectively reflect this buy quantity as a valid requirement in inventory management files and in budget stratifications.

Summary

While the overall procurement workload has decreased, the extent to which that decrease can be attributed to increases in order quantities is not certain. One reason for that uncertainty is that the number of items that were constrained to a 12-month minimum buy represents only a portion of total replenishment items and an even smaller portion of total procurement workload. Furthermore, given that there are alternative approaches to reducing workload and controlling unit costs, the use of increased order quantities on a blanket basis does not seem justified. Economic models are available to weigh the cost/benefit tradeoffs on a case-by-case basis. Thus, with standard solicitation of quantity discount alternatives, it is possible to automate the analysis of quantity discounts to effectively determine the option that will yield the lowest total annual cost to the Government. However, before these models can be applied as a standard part of the procurement process, they must become part of an automated analysis and communication system linking procurement and inventory control.

CHAPTER 3

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Our analysis of DoD order quantity policy over the past several years indicates that a reconciliation of existing guidance provided in DoDI 4140.39 and the current ICP operating environment, with its associated competing objectives and processing constraints, is needed. Such a reconciliation is both feasible and beneficial and the specific components or elements of the resulting order quantity policy are addressed in this chapter. The recommendations presented are based on the following summary conclusions drawn from our analysis:

- Strict application of EOQ principles in determining the order quantity fails to properly compensate for existing workload constraints at the ICPs and does not adequately recognize the possibility of quantity discounts on selected items. Balancing order costs and holding costs through the use of EOQ methods is a valid approach for determining general inventory requirements in stratification and budget development and for generating an initial target stock replenishment order quantity. However, this so-called EOQ should not be accepted as the ultimate *buy* quantity without adjustment as necessary for changes in demand, asset position, and available price-quantity discounts at the time of contract award. EOQ is an economic *order* quantity, not necessarily an economic *buy* quantity. The information necessary to determine an economic *buy* quantity is generally available only at the time of award.

- The ICP environment for managing spares and repair parts is highly volatile. Policy and procedural changes in many diverse functional areas generate additional workload, which affects the ability of the ICP to manage the resulting throughput. Procurement workload is highly susceptible to these changing requirements and is composed of several major elements, including initial provisioning buys, special program buys, end-use or direct turnover buys, base/administrative support buys, and stock replenishment buys. The future expected volume of each of these procurement workload elements is difficult to forecast. Relating them, as a group, to available procurement processing capability is even more difficult. Thus, the use of a specific procurement workload constraint in the development of order quantity requirements is not considered feasible.

- Spares and repair parts item demand, even for those items categorized as stable demand items, is highly variable. Significant demand changes occur even for these "stable demand" items with changes of 20 to 30 percent common (in both directions) over a 12-month period. This extreme demand volatility not only affects the ability of the system to accurately forecast demand for use in requirements determination it also introduces critical processing considerations into the development of order quantities. As we have discussed elsewhere, the combination of volatile demand, long procurement leadtimes, and large order quantities represents a clear prescription for potential inapplicable assets on hand and on order. Accordingly, recent growth in inapplicable assets should not come as a surprise to DoD inventory managers. However, small order quantities provide the inventory manager with the valuable flexibility to react more effectively to demand changes over time and to readily adjust follow-on buys to compensate for the inevitable swings in demand that characterize DoD secondary items. Thus, the argument that larger minimum 12-month buys do not affect the total quantity of material that would have been purchased over time are invalid in that they fail to recognize the inventory manager's ability to adjust more responsively to demand shifts.

- Opportunities for quantity discounts on a wide range of items do exist. Active solicitation of quantity alternatives (ranges or multiples of the purchase request quantity) generates tangible results for selected items. Based on the known price-quantity alternatives available to the buyer at the time of contract award, these options can be effectively evaluated with a minimum of additional effort. That evaluation can be made with existing mechanized evaluation models that determine the buy quantity that represents the lowest total cost to the Government at the time of contract award, considering both the price discount and the inventory investment cost tradeoffs. This selective approach permits the Government buyer to incorporate quantity discount information (together with demand and asset changes that have taken place during the ALT) in the actual buying process and affords the ICP the opportunity to selectively take advantage of these benefits without the related costs of unnecessary investment in inventory across a broad range of items in anticipation of unknown and unproven quantity discounts. While we recognize that demand volatility remains an issue to be resolved, we believe that the benefits of selectively using quantity discount options in terms of both workload and price paid are potentially substantial and that those alternatives should be pursued while analysis of the demand volatility problem is continuing.

- Other selective or tailored procurement techniques also appear highly beneficial for specific inventory segments and markets. Those techniques, which typically involve a multiyear contract period, include several forms of Indefinite Delivery Contracts (IDCs). Both quantity and delivery schedules may be flexible under such contractual arrangements. Requirements contracts represent one primary application of this selective approach to choice of contract instrument. The clear benefit here is the ability to take advantage of the item's demand characteristics and of the market in which the item is procured by establishing a viable source of supply with potential quantity and delivery flexibility over an extended period of time. Both workload and inventory investment would decrease.

- Given the dynamic nature of the ICP inventory management and procurement environment, the optimal buy quantity can be determined only at the time of contract award because the full range of information necessary to make the determination of lowest total cost to the Government is available to the ICP only at this point. Further, the information technology is available to utilize this key information at the point of award to make reasoned, timely buy quantity decisions in parallel with the contract award.

- As a result, a separation of the order quantity decision from the buy quantity decision is inevitable in order to manage the entire process in a cost-effective manner. The policy implications of this shift are dramatic. The approach essentially recognizes that for inventory management purposes, the basic cost tradeoffs between order cost and holding cost must be recognized as valid and appropriate in development of requirements and in providing a foundation for solicitation. At the same time, the strategy provides an effective vehicle for dealing with real price differentials associated with the buy quantity by acquiring and using the specific vendor data necessary to effectively evaluate and exploit these opportunities. It represents a reconciliation of two diverse but equally valid views of the replenishment process.

- Finally, while today's ICP information processing systems have many of the capabilities necessary to implement the strategic policy thrust briefly noted above, these capabilities are generally not fully integrated into main, on-line processing systems. Those systems provide no real mechanized feedback to inventory management files and have not been utilized with the processing volumes anticipated under this concept. Accordingly, the move to an order quantity policy, where the actual buy quantity is determined at point of award for a large range of spares and repair parts replenishment buys, must be supported by the basic information processing system to accommodate the additional analysis without increasing processing times and resources. Two specific systems changes are necessary. First, the off-line evaluation models now in use should be integrated to the extent feasible into the normal on-line ICP processing flow. Second, when the Government buyer purchases a quantity larger than the purchase request quantity, the inventory management and stratification processes must be revised to adequately recognize that decision as a valid requirement. Third, an appropriate budget formulation process must be developed to effectively fund purchase quantities larger than the computed purchase request quantity.

These summary conclusions lead to the formulation of a series of specific policy recommendations. We examine these policy recommendations in two general categories:

- System Policy Recommendations
- Technical Policy Recommendations.

SYSTEM POLICY RECOMMENDATIONS

From an overall system perspective, current wholesale order quantity policy should be revised to provide the necessary flexibility and responsiveness required to deal with the dynamic ICP and vendor/market environment. Continued reliance on arbitrary order quantities established on a blanket basis without regard to line-item characteristics and without proper recognition of the risks of inapplicable assets cannot be supported. At the same time, a return to traditional EOQ approaches is equally undesirable in terms of recognizing the real price-quantity options that are available. A basic strategic change in direction is necessary, a change that will exploit existing market opportunities on a selective basis while integrating the efforts and objectives of the inventory management and procurement functions at the ICP. Accordingly, we recommend that the Assistant Secretary of Defense for Production and Logistics [ASD (P&L)] revise current wholesale spares and repair part order quantity policy as follows:

- Discontinue the use of the minimum 12-month order quantity floor and any other larger minimum order quantity floors currently in use by the Services.

- Re-establish the use of EOQ methods for development of stratification and budget requirements and for generating a target order quantity for purchase request purposes. This EOQ approach should be designed to recognize the economic tradeoffs between order cost and holding cost and should not include shortage cost as a parameter.

- Limit EOQ quantities on a given line item to 36 months of material as an upper bound and to the current ALT level (measured in months) for the given line item as a lower bound. The upper bound is consistent with current policy and recognizes the forecasting difficulties faced by DoD inventory managers. The lower bound will conceptually preclude simultaneous processing of multiple stock replenishment actions and is an effective way to accommodate workload considerations in the EOQ computation.

- Limit the override of the computed EOQ in developing the target order quantity to those specific instances and line items for which past vendor data support an alternative quantity. The decision to alter or revise the recommended EOQ should be made by the inventory manager on an individual line item basis, given specific supporting data. An audit trail should be established and maintained to document such override decisions.

- Routinely solicit quantity discount ranges (as multiples of the purchase request quantity) in solicitations. Given the proven success of this approach in creating opportunities for the DoD to make cost-effective buy decisions, this technique should be a standard part of most spares and repair part procurements. The quantity discount approach to solicitation and contract award provides DoD the flexibility to adjust to demand and asset changes during the ALT and at the same time effectively generates price-quantity options where they exist; those options can typically be employed directly in the award without further interaction with vendors. Moreover, the method also gives the bidders incentives to provide price breaks where production and cost economies will allow.

- Determine the actual buy quantity at the time of contract award using the quantity discount information (and other relevant data such as current demand/asset data) by adjusting the purchase request target order quantity. This approach allows the buyer to be selective in that the recommended order quantity would be adjusted in the buying process only in those specific instances in which the price-quantity data indicate a lower total cost to the Government that can be defended based on known line item data. The actual buy quantity, determined by the buyer in consultation with the inventory manager when necessary, should be dynamic and should be determined by the input of price-quantity options into a structured evaluation model which will mechanically compute total cost to the Government for each option and will recommend the optimal buy quantity to the buyer for an award decision. Total cost to the Government would include not only the actual material costs associated with each option but would also consider transportation, inventory investment, and relevant administrative costs in making a recommendation. The Navy, Air Force, and DLA have such models and use them at the ICPs on a selective, off-line basis. They are computationally sound and provide auditable and defensible logic to support award decisions. In the near term, these models will provide the capability to introduce the dynamic order quantity policy recommended here. In the long term, the full extension of the dynamic order quantity policy will require revision of mainline inventory management and procurement systems and an explicit treatment of the risk of inapplicable assets associated with larger buy quantities.

- Expand the use of tailored, multiple-year purchasing methods, such as IDCs and requirements contracts, which allow exploitation of quantity-price relationships yet retain flexibility to adjust to changing demand conditions and minimize the initial investment in inventory. The innovative use of these contract tools and methods, which combine the benefits of price breaks for larger contract quantities and the benefits of phased deliveries to minimize investment in inventory, should be encouraged by direct Service/DLA Headquarters-level emphasis and involvement. Formal action programs or initiatives may represent the most effective means to stimulate actions in this area. Those Service or DLA action programs should recognize the increased initial front-end resource costs of establishing the contractual vehicles necessary to execute the program. Overall, however, we believe that for selected items these methods represent a viable means to reduce procurement workload, realize price advantages, and minimize inventory investment.

- Develop the necessary information processing system capabilities to allow the full implementation of the dynamic order quantity policy as a part of standard ICP processing. As routine solicitation of quantity discount options is extended to the broad spares and repair parts inventory, the application of current off-line models will not be feasible without significant resource impacts at the ICP. Not only should vendor responses to quantity discount solicitations be maintained by line item in an appropriate data base for future information but the results of the buying decision as to the appropriate buy quantity should be used to automatically update both inventory management and procurement files without further manual input. Finally, the necessary coordination and communication between buyer and inventory manager on the actual buy quantity should be incorporated in the design of the mainline processing system.

- Develop the requisite budgeting and stratification processes to identify and support funding requirements for quantity-discount buys (and other buys beyond the computed buy quantity) and to recognize on-hand and on-order assets procured using these methods as applicable assets.

TECHNICAL POLICY RECOMMENDATIONS

To support the basic policy direction recommended above, a number of technical changes in policy and procedure are also required. These more-specific changes, some appropriate for updating DoDI 4140.39, provide the underlying structure, rationale, and computational detail to implement the major policy direction recommended. Specifically, we recommend that the ASD(P&L) review and revise DoDI 4140.39, DoDI 4140.24, and related directives to include the following policy provisions:

- Compute EOQs by considering only order costs and holding costs in determining economic tradeoffs. Eliminate the use of shortage cost as a parameter in the Total Variable Cost equation to determine the EOQ.

- Standardize and simplify the determination of order costs to provide consistency across ICPs and over time. Review the current detailed order cost worksheet to define terms more clearly and to eliminate redundancy. Incorporate in the order cost analysis, specific consideration of actual historical total procurement costs and associated workload in identified categories.

- Revise the treatment of the capital cost parameter in developing the holding cost rate. Discontinue the use of a fixed 10 percent cost of capital and replace it with a variable cost of capital; have the Military Services and DLA update that variable cost on an annual cycle based on the existing 90-day Federal funds rate. Coordinate this change with appropriate OSD and OMB personnel.

- Revise the current computation of the obsolescence rate used as part of the overall holding cost rate. In addition to considering the dollar volume of actual disposal actions relative to the investment in inventory, the marginal rate of change in total inapplicable assets on hand, or inapplicable assets on hand in selected retention categories, should also be a factor in determining the dollar value of inventory that has essentially become "obsolete" relative to projected use or application.

- Use the computed EOQ as the basic order quantity requirement in stratification and budget development, in inventory control models, and in generating purchase requests for stock replenishment as the recommended order quantity.

- Limit EOQ quantities on a given line item to 36 months of material as an upper bound and to the current administrative leadtime level (measured in months) for the given line item as a lower bound.

- Reconfirm the desirability of selectively adjusting the recommended order quantity at the time of contract award to recognize the dynamics of the procurement and inventory management environment at the ICP and to explicitly take advantage of actual price-quantity options available at the time of the buy decision for a given line item.
- Ensure that order costs and holding cost rates be updated no less frequently than once a year or as significant changes occur.
- Require that current order costs and holding cost rates be submitted as a part of each secondary item budget submission to support the stratified procurement cycle requirement.
- Use order cost and holding cost rate changes over time (both at a given ICP and across ICPs) to review and analyze ICP spares and repair parts budget submissions.

SUMMARY

In total, the system and technical policy recommendations outlined above will provide the necessary balance in the near term between investment in spares and repair parts inventories and the timely, cost-effective replenishment of those inventories. By linking the order quantity decision directly to the buying decision, the dynamic order quantity approach presented uses existing information technology to ensure that all available information is incorporated at the time of the award to achieve lowest total cost to the Government. The inventory management strategy rests on proven EOQ trade-off concepts as the foundation for the development of budget requirements and recommended procurement quantities. At the same time, the procurement strategy is based on selectively exploiting demonstrated price breaks to reduce material acquisition costs and on the use of tailored procurement methods to manage procurement workload.

APPENDIX A

STUDY SCOPE AND METHODOLOGY

SCOPE

This study examines the policies and procedures used to compute DoD wholesale spares and repair part item replenishment order quantities. It encompasses the general categories of spares and repair parts, both consumables and reparables, currently managed by the Military Services and the Defense Logistics Agency (DLA) under continuous review, reorder point replenishment models that employ a specific order quantity or operating level in the overall computation of requirements. Air Force wholesale reparables are thus specifically excluded. For those item categories outlined above, we focus specifically on the following 12 research issues:

- How are order quantity requirements developed by the Services and DLA and how have their approaches changed since FY83?
- How and when were minimum order quantity floors increased from the level specified by DoDI 4140.39 to the minimum 12-month floors in place in FY87?
- How are the parameters necessary to determine Economic Order Quantity (EOQ) requirements under DoDI 4140.39 guidance developed, how have they changed over time, and how consistent and valid are they when evaluated across the Military Services and DLA?
- Based on documented changes in computational method, input parameters, and minimum order-quantity floors, how have overall Service and DLA wholesale order quantity requirements increased since FY83?
- What changes have taken place in inapplicable on-hand and on-order assets since FY83?
- Specifically, what effect have larger order quantities had on the incidence and magnitude of inapplicable on-hand and on-order assets since FY83?
- How have larger order quantities affected overall inventory control point (ICP) procurement workload and processing times?

- How have larger order quantities affected ICP buying methods and contracting techniques?

- How did Service and DLA ICPs implement the August 1985 Federal Acquisition Regulation (FAR) provision regarding solicitation of Economic Purchase Quantities (EPQs) from vendors, and what effect has that FAR provision had?

- How are ICP decisions to procure multiples of the computed order quantity (via vendor quantity discounts) implemented in ICP inventory management files and in the subsequent requirements determination process?

- What audit tools or evaluation methods have been developed to allow the ICP to effectively analyze alternative price-quantity combinations to make contract awards?

- Is it possible to reconcile traditional EOQ approaches to order quantity determination with the current DoD ICP inventory management and procurement operating environment?

To fully evaluate these research issues, we specifically identified the 10 Service and DLA ICPs shown in Table A-1. In combination, these ICPs provide a broad, representative sample of spares and repair part items managed and therefore provide a reasonable base for extrapolation of results. In addition, we drew aggregate budget data from the full range of Service and DLA ICPs and also developed a large line-item sample from eight Service/DLA ICPs; that sample includes approximately 800 consumable items.

METHODOLOGY

In order to complete the analyses, our review included three major elements and associated data sources:

- At the aggregate level, we used opening position stratification data to document and analyze changes in wholesale spares and repair parts order quantity requirements over time. Other sources – primarily budget documents – also portray order quantity requirements. However, given the adjustments that take place in the budget development process, these budget-based order quantity requirements generally differ from those shown in the stratification data. Where stratification data are cited in the report, the database includes both consumables and reparables for the Army and the Navy and only consumables for the Air Force and DLA. Called the Procurement Cycle Requirements (PCR) in stratification displays, these data were available at the ICP level for FY83 through FY87. We used these aggregate data on PCR to document the growth in

TABLE A-1

DoD ICPs SURVEYED

Service	ICPs surveyed
Army	Army Missile Command (MICOM)
	Army Aviation Systems Command (AVSCOM)
	Army Communications-Electronics Command (CECOM)
Air Force	Oklahoma City Air Logistics Center (OC ALC)
	Warner-Robins Air Logistics Center (WR ALC)
Navy	Navy Aviation Supply Office (ASO)
	Navy Ships Parts Control Center (SPCC)
DLA	Defense Electronics Supply Center (DESC)
	Defense General Supply Center (DGSC)
	Defense Industrial Supply Center (DISC)

replenishment-based PCR from FY83 to FY87. Both absolute PCR dollar growth and relative PCR growth (in months of demand) were computed and analyzed. This aggregate picture of DoD spares and repair part PCR thus forms an initial framework for more detailed examination of specific ICP and selected line-item data and was used as an opening position for subsequent dialogue with the Military Services and DLA. We also used this aggregate stratification data to evaluate the overall level and change in inapplicable assets on hand and on order. Budget documentation and the *Annual DoD Physical Inventory Report* are alternative sources for data on inapplicable assets but, given differences in the methods used and scope of coverages, reflect different results. Again, our analysis addressed both the level and growth in the absolute dollar value of inapplicable on-hand and on-order assets as well as the relative level and growth of those inapplicable assets (as measured in months of demand). In addition, we looked at the percentage of on-hand and on-order assets that was identified as inapplicable and at how that percentage had changed over time. Results of this analysis are identified in this report as aggregate budget/stratification results and data.

- At the individual ICP level, we conducted extensive survey analyses at the 10 ICPs noted in Table A-1. Using a prepared questionnaire provided to the ICPs in advance, we conducted 2-day site visits to each activity to examine each of the 12 research issues. These site visits included in-depth interviews; examination and collection of ICP operating data; analysis of ICP management policies, procedures, and systems; and line-item reviews in both inventory management and procurement files. From these ICP surveys, we were able to determine the timing and method of implementation of the minimum 12-month order quantity floor; the impact of that change in order quantity policy on ICP inventory investment and procurement workload; changes in ICP inapplicable assets on hand and on order; methods used to update order cost and holding cost parameters at the ICP; and changes in basic procurement methods and techniques that had proven successful at the ICP in either reducing workload, exploiting price-quantity tradeoffs, or both. Results of this analysis are identified in this report as ICP survey data and results.

- Finally, in pursuing the question of the impact of order quantity size on the incidence and magnitude of inapplicable on-hand and on-order assets, we used a specific line-item sample of consumable items first identified by the Department of Defense Inspector General (DoDIG) in its 1986 review of wholesale order quantities. Approximately 900 items were extracted from ICP files in 1986. Those specific items, pulled from eight Service/DLA ICPs, were identified by those ICPs as items whose computed EOQ was less than 12 months and as items for which design and demand were considered stable enough to increase the minimum order quantity to twelve months. The initial sample was approximately 888 line items as shown in Table A-2. Based on a 1987 data extract, we were able to generate a follow-on data sample for 789 of those 888 line items, which allowed us to evaluate changes that had taken place over the intervening period. We analyzed these specific line items using multiple regression techniques to determine those key independent variables, including the size and percentage change in order quantity, that appear to consistently influence the incidence, magnitude, and percentage change in inapplicable assets on hand or on order. Statistical significance tests are employed as appropriate to portray the results.

TABLE A-2

LINE-ITEM SAMPLE DATA

DoD Component	1986 line-item sample	1987 matching line-item sample
Army	115	98
Air Force	240	208
Navy	235	210
DLA	298	273
Total	888	789

APPENDIX B

ORDER QUANTITY REQUIREMENTS ANALYSIS

PURPOSE

The changes in the minimum constraints (12-month floor in place of a 3-month floor) applied to spares and repair part wholesale order quantities have had significant effects on procurement cycle requirements (PCRs). This appendix discusses the magnitude of the growth in PCRs, as reflected in the spares and repair part stratification summaries from FY83 to FY87.

Overall growth in PCRs from the summary stratification reports is portrayed first. The summary reports include assets and requirements for all materiel, including demand-based, insurance, and provisioning items. Next, to exclude the effect of the changes in provisioning requirements, special program requirements, and nondemand-based items, the growth in PCRs from the replenishment stratification reports are discussed. Finally, we show the cost of the growth in demand-based PCRs.

The analysis of Air Force data is restricted to consumable items.

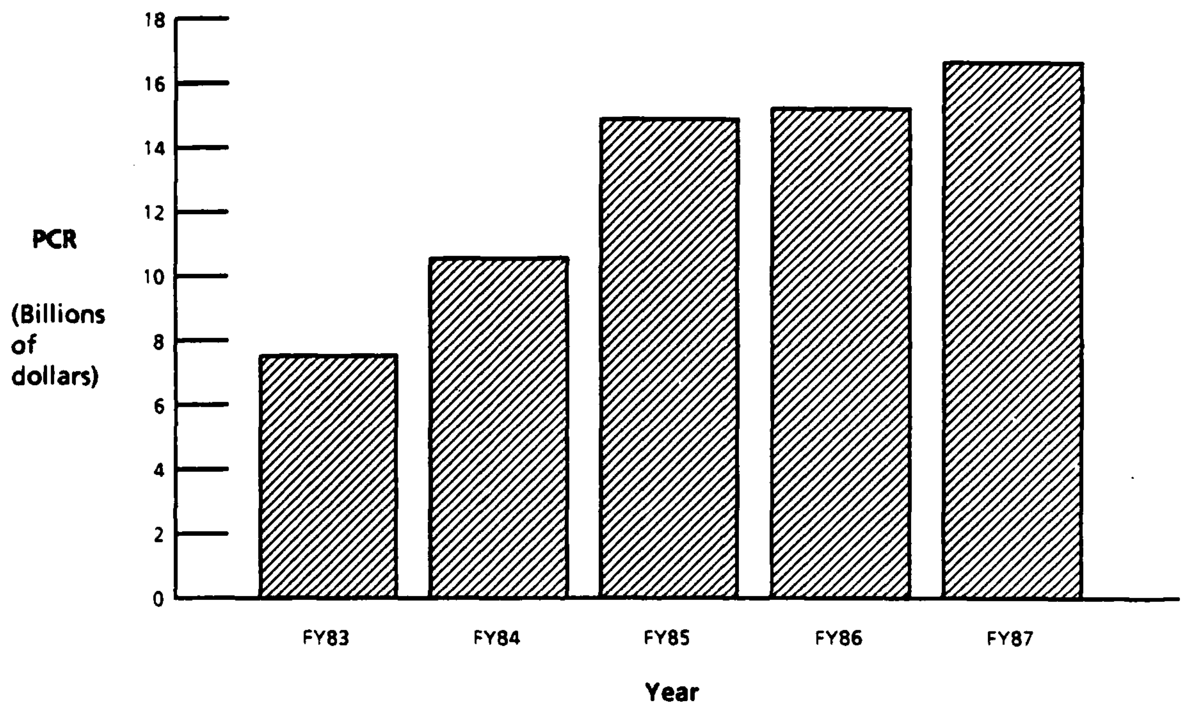
IMPLEMENTATION OF THE 12-MONTH ORDER QUANTITY

The trends in order quantity growth should be considered in view of the timing of the implementation of the 12-month minimum constraint on order quantities.

- *Army.* Implemented in the second half of FY84.
- *Navy.* At the Aviation Supply Office (ASO) implementation was phased from October 1984 to June 1985. At the Ships Parts Control Center (SPCC) implementation was phased from September 1982 to December 1984.
- *Air Force.* Implemented in the first quarter of FY84.
- *Defense Logistics Agency (DLA).* Implemented for selective items starting in the first quarter of FY84. DLA *rescinded* the 12-month minimum order quantity in July 1986.

SUMMARY TOTAL STRATIFICATION DATA

The opening position PCR for the Services and DLA have been totaled from the summary stratification reports from FY83 through FY87. A graphic representation of the growth in the total DoD PCR is shown in Figure B-1, while the trends in the individual DoD Components are reflected in Figure B-2. The data illustrated in these graphs is shown in Table B-1. The overall growth in DoD PCR from FY83 to FY87 was 121 percent. Total PCR as a *percentage* of the FY83 PCR is depicted in Figure B-3.



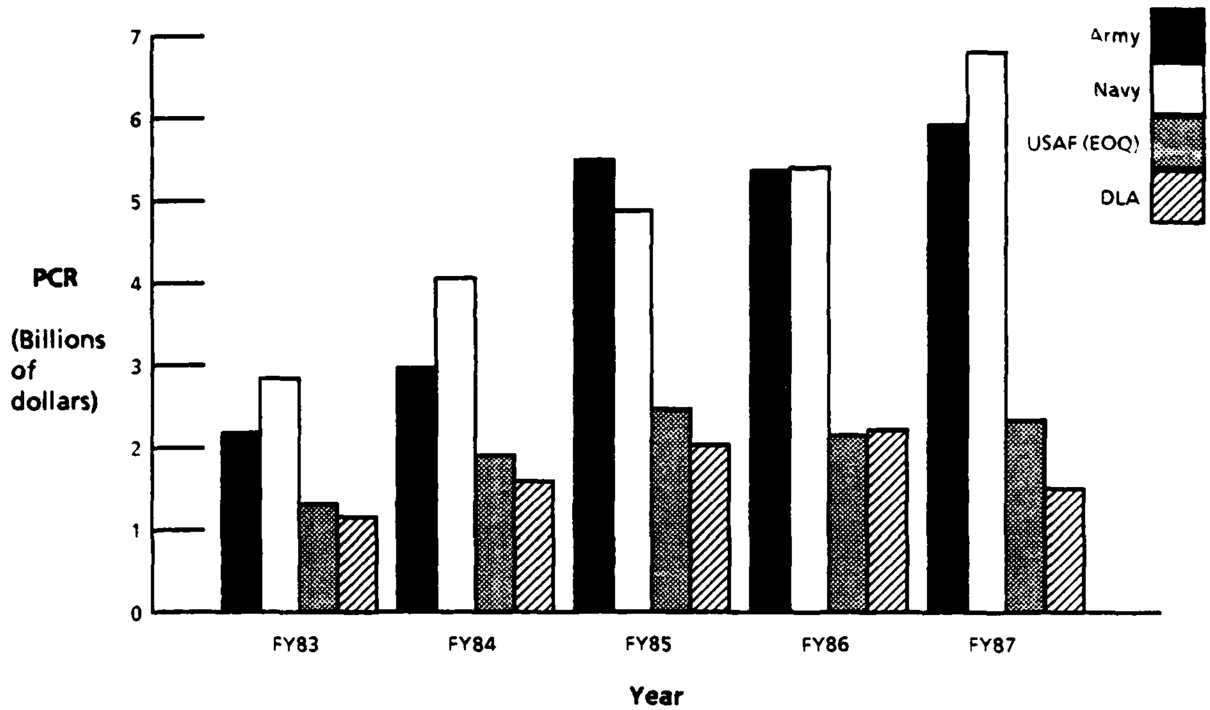
Source: Service/DLA stratification data.

FIG. B-1. TOTAL DoD PROCUREMENT CYCLE REQUIREMENTS

REPLENISHMENT STRATIFICATION DATA

The DoD Components produce replenishment stratification reports that exhibit the direct or pure effect of the 12-month minimum constraint on order quantities more appropriately than do the summary reports.

The replenishment stratification reports exclude new items and items still within their demand-development period, which is usually 24 months following the



Source: Service/DLA stratification data.

FIG. B-2. TOTAL PROCUREMENT CYCLE REQUIREMENTS

fielding of the supported system. Those items are included in provisioning reports. The Navy also excludes from its replenishment reports items that have demand forecasts of less than one per quarter; it includes those items in its insurance stratification report. DLA and the Army exclude insurance stock from their replenishment reports and aggregate them in separate stratification reports. The Air Force replenishment reports, coded X5F, include *both* insurance and demand-based items.

The analysis of replenishment PCR identifies the trends in the demand-based requirements, in both dollars and months. "Replenishment PCR" is defined as the opening position PCR from the replenishment stratification report minus the value of that part of the PCR not demand-based, i.e., "program requirements." The Navy reports identify the program requirements in a memo entry labeled "PCRPRO." For the Army, the Air Force, and DLA, the nonrecurring demand memo entry from the

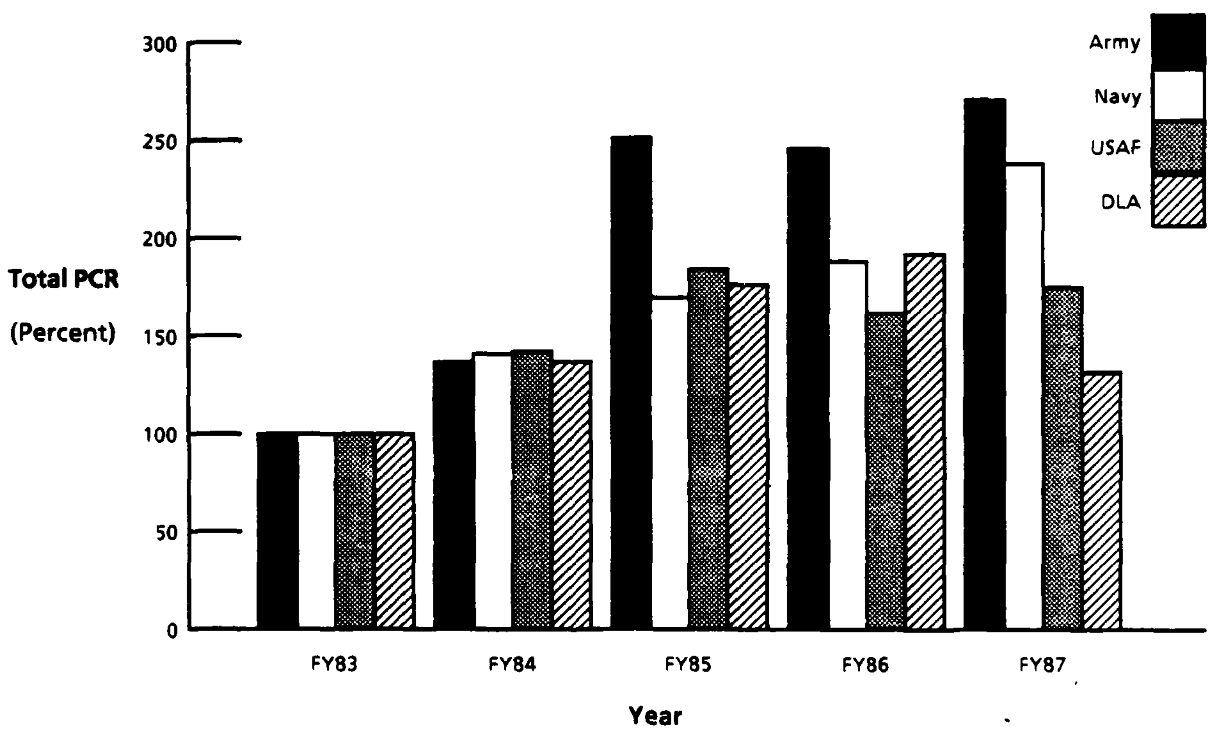
TABLE B-1

GROWTH IN TOTAL PROCUREMENT CYCLE REQUIREMENTS

(Current dollars in thousands)

DoD Component	FY83	FY84	FY85	FY86	FY87
Army	$ 2,186,947	$ 2,994,881	$ 5,502,022	$ 5,391,132	$ 5,956,404
Navy	2,867,191	4,073,308	4,879,928	5,426,818	6,838,932
USAF	1,339,168	1,916,138	2,475,165	2,175,709	2,360,004
DLA	1,157,138	1,596,709	2,052,081	2,236,911	1,531,525
Total	$ 7,550,444	$ 10,581,036	$ 14,909,196	$ 15,230,570	$ 16,686,865

Source: Service/DLA stratification data. March stratifications were used for Services and June, for DLA. FY83 Navy data are from the 9/83 stratification.



Source: Service/DLA stratification data.

FIG. B-3. TOTAL PCR AS PERCENTAGE OF FY83 TOTAL PCR

budget year was used to estimate and eliminate the nondemand-based portion of the PCR.

To estimate the number of months of stock represented by replenishment PCR, the ratio of replenishment PCR to recurring demand was used. The exception to this approach was the analysis of Army data since the Army stratification reports explicitly display the PCR months. For DLA and the Air Force, the budget year demand forecasts were used. As recommended by the Naval Supply Systems Command, the annualized current year demand forecast was used for SPCC while the budget year demand forecast was used for the ASO. All demand values used in the analysis were net of estimated recoverables from unserviceable returns.

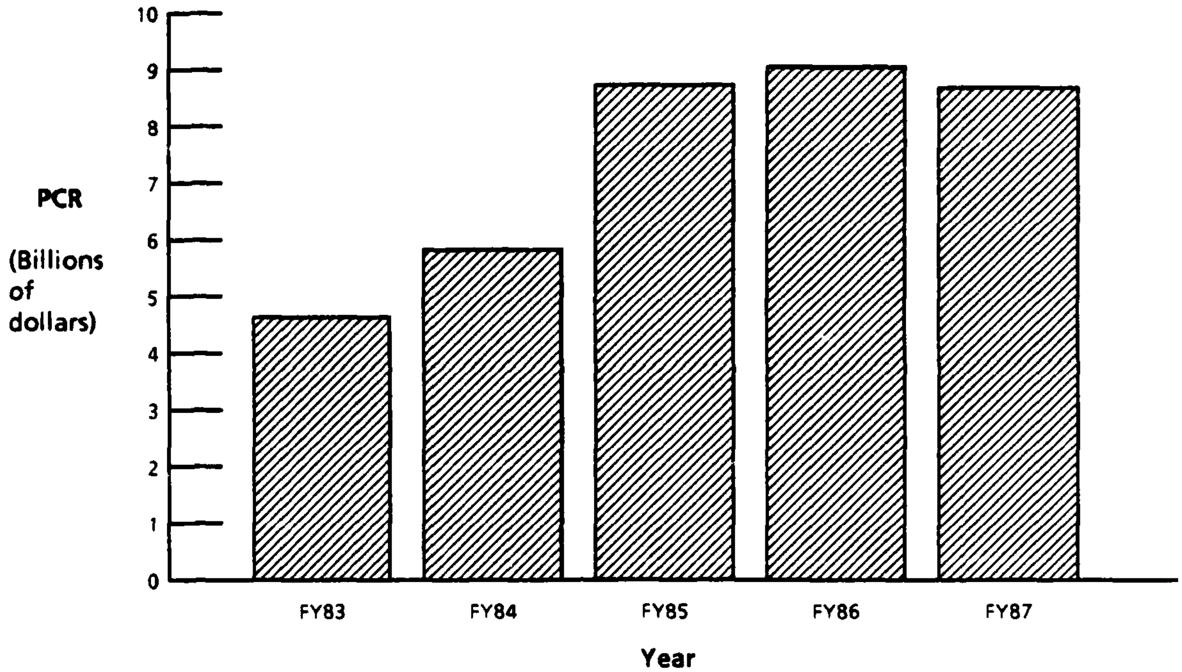
Replenishment PCR Growth in Dollars

Total DoD replenishment PCRs grew from $4.7 billion in FY83 to $8.7 billion in FY87, a growth of 86 percent. The FY86 replenishment PCR was $9.1 billion, or 94 percent greater than in FY83, but DLA's cancellation of its 12-month order quantity constraint in July 1986 reduced the total DoD replenishment PCR in FY87. Figure B-4 shows the trend in total DoD replenishment PCR, while Figure B-5 shows the trends in the Services and DLA. The data reflected in those figures are shown in Table B-2. Figure B-6 portrays the replenishment PCRs as a *percentage* of the FY83 requirement, with supporting data in Table B-3.

Replenishment PCR Growth in Months

Figure B-7 shows the trend in replenishment PCR months, with supporting data in Table B-4. The selective use of the 12-month minimum order quantity by DLA, as opposed to the more comprehensive application by the Services, is clearly seen in Figure B-7. The computed Air Force replenishment PCR monthly averages for each fiscal year are less than 12 because the Air Force includes demand for "Type C computation" items, e.g., insurance stock, in the replenishment report demand forecasts. Those items are not assigned a PCR, but since they contribute to the aggregate demand forecasts, their inclusion in the replenishment reports reduces the computed PCR months. Unfortunately, it was not possible to isolate the effect of the Type C computation items.

Replenishment PCR months as a *percentage* of FY83 PCR months is shown in Figure B-8. From that perspective the PCR changes in the Services appear much



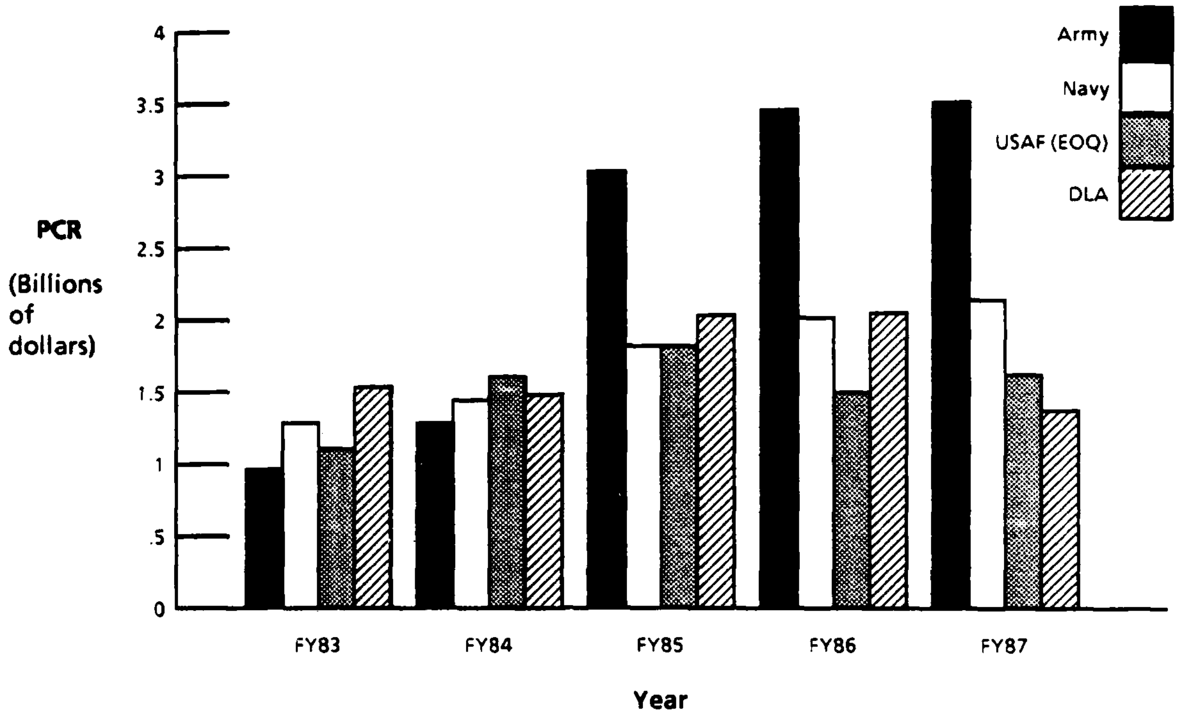
Source: Service/DLA stratification data.

FIG. B-4. REPLENISHMENT DoD PROCUREMENT CYCLE REQUIREMENT

more uniform in recent years than when considered in absolute dollars or computed months. The supporting data from Figure B-8 are seen in Table B-5.

COST OF PCR GROWTH

Table B-6 reflects the growth in the months of PCR multiplied by the dollar value of 1 month of PCR. For the Services, PCR growth in months from FY83 to FY87 was used, times the value of one PCR month in FY87. Since DLA *rescinded* its 12-month minimum order quantity prior to FY87, using the FY87 PCR months would not accurately reflect what the cost would have been if the policy were perpetuated. For that reason, the PCR months and the cost of one PCR month from FY86 were used in Table B-6 for DLA. Given the total dollar increase in replenishment PCR the associated annual holding cost to DoD approximates $300 million. When the dollar growth in total PCRs is considered ($9, 136, 421), the related annual holding cost to DoD is $670 million.



Source: Service/DLA stratification data.

FIG. B-5. REPLENISHMENT PROCUREMENT CYCLE REQUIREMENTS

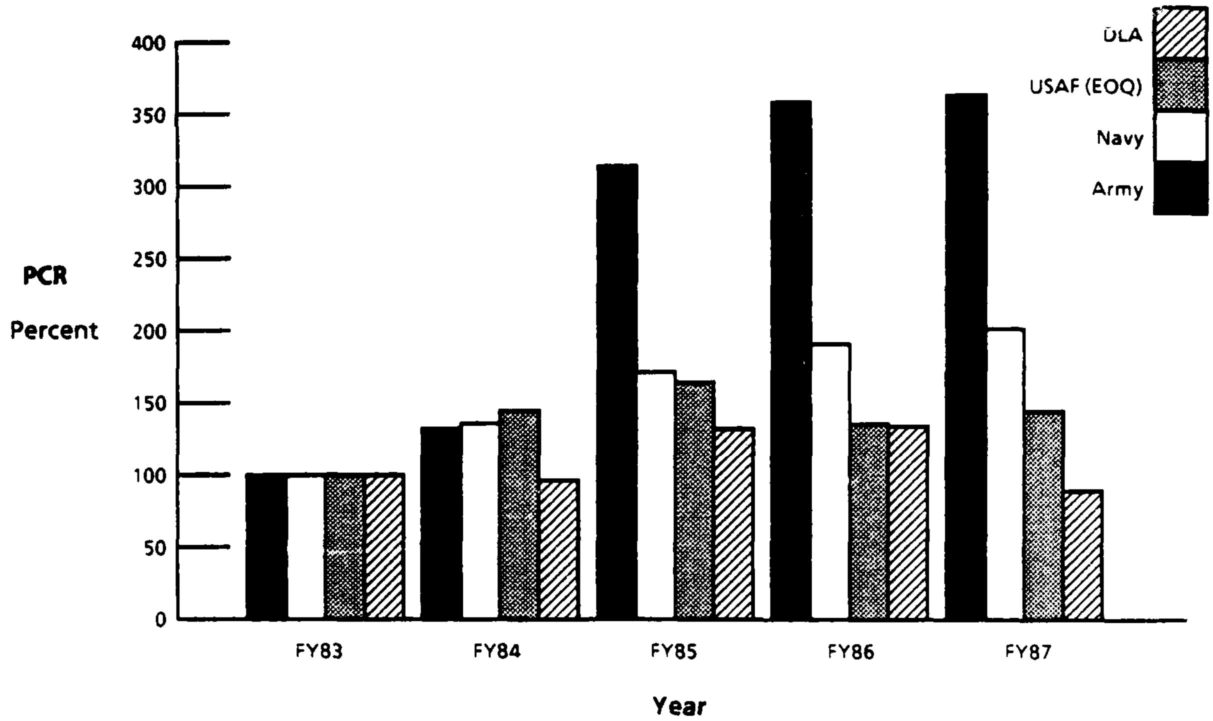
TABLE B-2

GROWTH IN REPLENISHMENT PROCUREMENT CYCLE REQUIREMENTS

(Current dollars in thousands)

DoD Component	FY83	FY84	FY85	FY86	FY87
Army	$ 965,821	$ 1,286,676	$ 3,037,554	$ 3,467,796	$ 3,527,357
Navy	1,061,244	1,453,373	1,833,207	2,034,842	2,149,315
USAF	1,112,672	1,620,519	1,838,485	1,510,672	1,628,243
DLA	1,538,434	1,487,901	2,040,331	2,066,359	1,389,039
Total	$ 4,678,171	$ 5,848,469	$ 8,749,577	$ 9,079,669	$ 8,693,954

Source: Service/DLA stratification data. March stratifications used for Services; June, for DLA. FY83 Navy data are from the 9/83 stratification.



Source: Service/DLA stratification data.

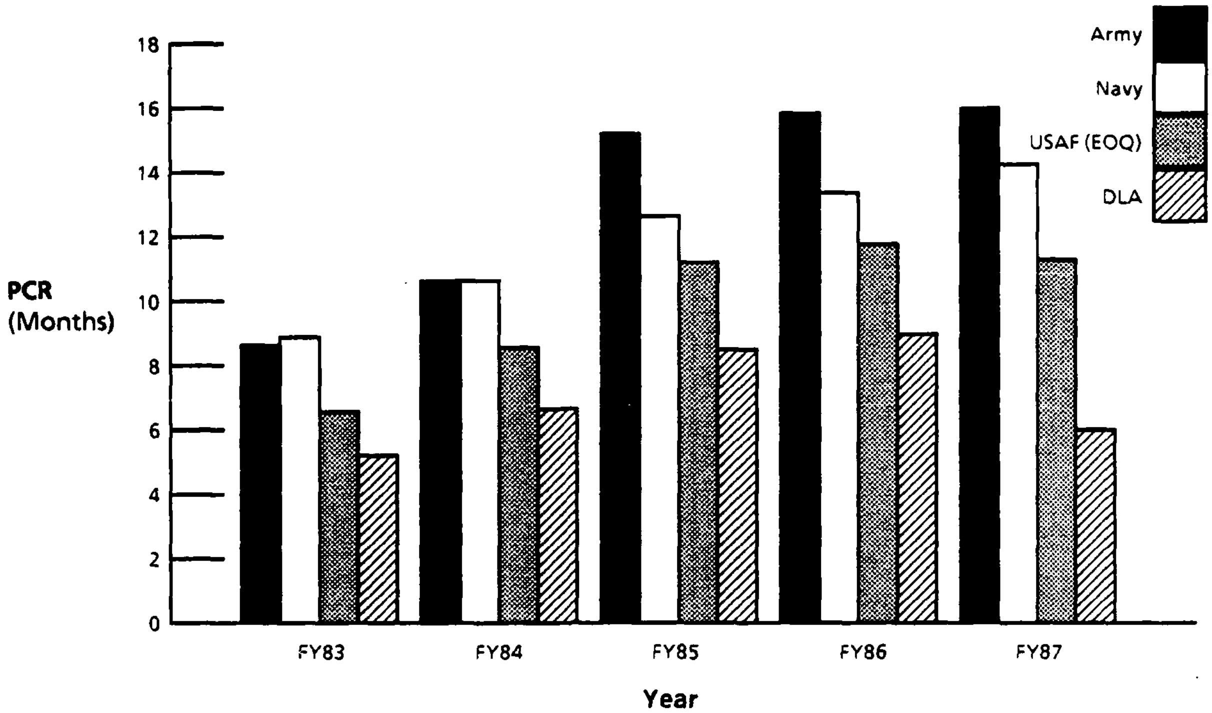
FIG. B-6. REPLENISHMENT PCR AS PERCENTAGE OF FY83 REPLENISHMENT PCR

TABLE B-3

REPLENISHMENT PCR AS PERCENTAGE OF FY83 REPLENISHMENT PCR

DoD Component	FY83	FY84	FY85	FY86	FY87
Army	100	133	315	359	365
Navy	100	137	173	192	203
USAF	100	146	165	136	146
DLA	100	97	133	134	90
Total	100	125	187	194	186

Source: Service/DLA stratification data. March stratification used for Services; June, used for DLA. FY83 Navy data are from 9/83 stratifications.



Source: Service/DLA stratification data.

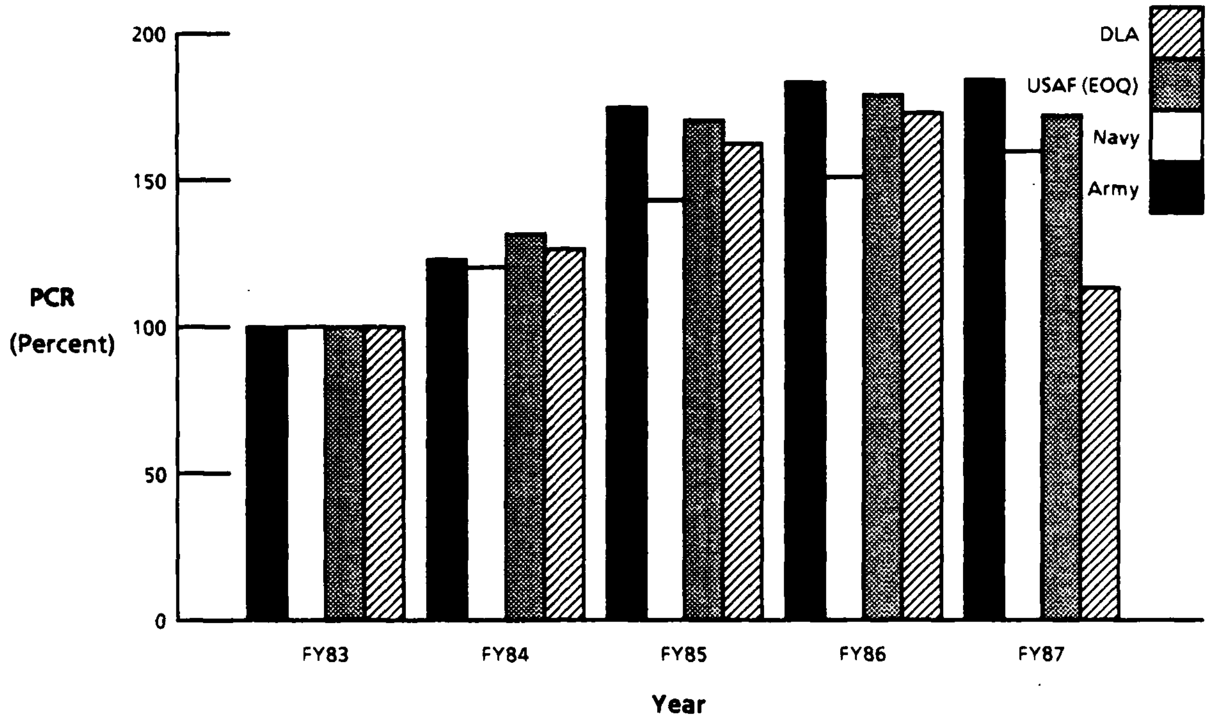
FIG. B-7. REPLENISHMENT PROCUREMENT CYCLE REQUIREMENTS MONTHS

TABLE B-4

REPLENISHMENT PCR GROWTH IN MONTHS

DoD Component	FY83	FY84	FY85	FY86	FY87
Army	8.7	10.7	15.2	15.9	16.0
Navy	8.9	10.7	12.7	13.4	14.3
USAF	6.6	8.6	11.2	11.8	11.3
DLA	6.7	6.2	8.5	9.0	6.0
Total	7.1	9.1	12.3	13.1	13.1

Source: Service/DLA stratification data. March stratifications used for Services; June, used for DLA. FY83 Navy data are from the 9/83 stratifications.



Source: Service/DLA stratification data.

FIG. B-8. REPLENISHMENT PCR MONTHS AS PERCENTAGE OF FY83

TABLE B-5

REPLENISHMENT PCR MONTHS AS PERCENTAGE OF FY83 REPLENISHMENT PCR MONTHS

DoD Component	FY83	FY84	FY85	FY86	FY87
Army	100	123	175	184	185
Navy	100	121	143	151	160
USAF	100	132	171	179	172
DLA	100	127	163	173	114

Source: Service/DLA stratification data. March stratifications used for Services; June, used for DLA. FY83 Navy data are from the 9/83 stratifications.

TABLE B-6

GROWTH IN REPLENISHMENT PCR

DoD Component	Dollar-value of one replenishment PCR month ($000)	Growth in dollar-weighted replenishment PCR months	Dollar-value of replenishment PCR growth ($000)
Army	$220,104	+ 7.37	$1,622,737
Navy	150,652	+ 5.35	806,330
USAF	143,946	+ 4.75	683,604
DLA	228,761	+ 3.81	872,213
Total	$743,463	+ 5.36	$3,984,884

Source: Service/DLA stratification data.

Notes: DLA PCR value from FY86; DLA PCR growth from FY83 to FY86 because 12-month floor was removed 7/86. Service PCR values from FY87. PCR growth from FY83 to FY87.

APPENDIX C

ANALYSIS OF INAPPLICABLE ON-HAND AND ON-ORDER ASSETS

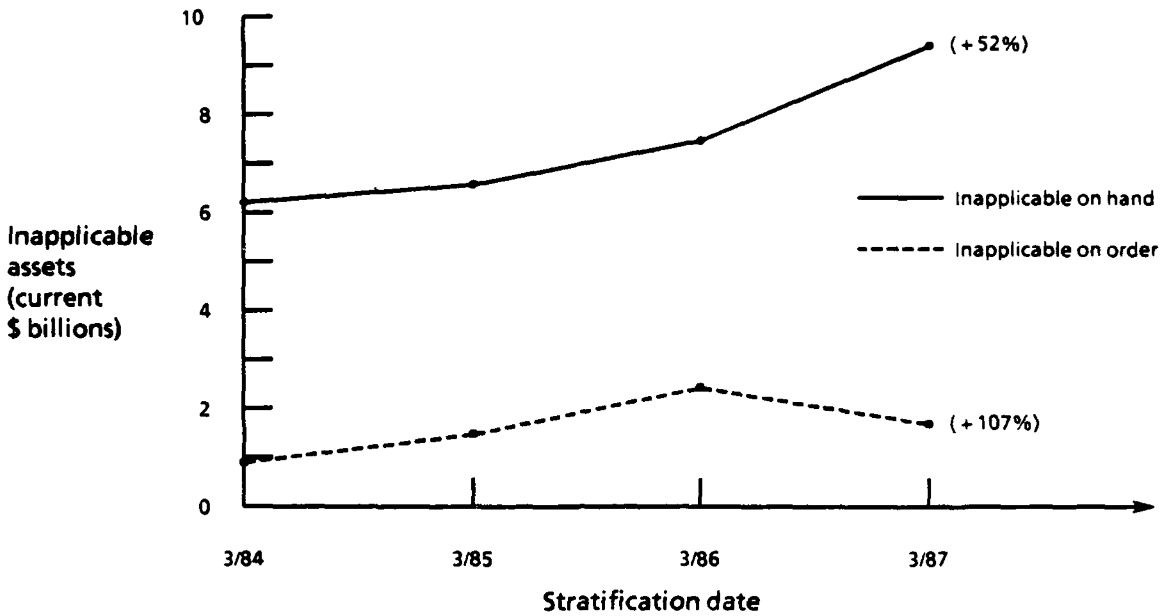
Since FY84, growth in wholesale spares and repair part demand, accompanied by increases in procurement leadtimes, safety levels, and order quantities have combined to increase overall DoD requirements. That increase has been accompanied by growth in inapplicable materiel inventory on hand and on order, assets that exceed immediate materiel requirements. These assets, both on hand and on order, are inapplicable to immediate requirements because they exceed the Approved Force Acquisition Objective (AFAO). (The AFAO is that quantity of an item that is authorized to equip and sustain U.S. Approved Forces in peacetime and wartime.)

In this appendix, we first examine changes in inapplicable assets on hand and on order on an aggregate basis across each Service and the Defense Logistics Agency (DLA) and then, in more detail, examine them at a more specific level based on a sample of individual line items. The overall macro changes – the aggregate – in the total DoD inventory picture discussed in the next section are developed from Service and DLA stratification data, which include data for all Army and Navy consumables and reparables, Air Force consumables, and the four DLA hardware ICPs. The line-item analysis – the micro analysis – is developed from a data sample drawn from specific wholesale inventory managers and represents consumable items only.

AGGREGATE ANALYSIS

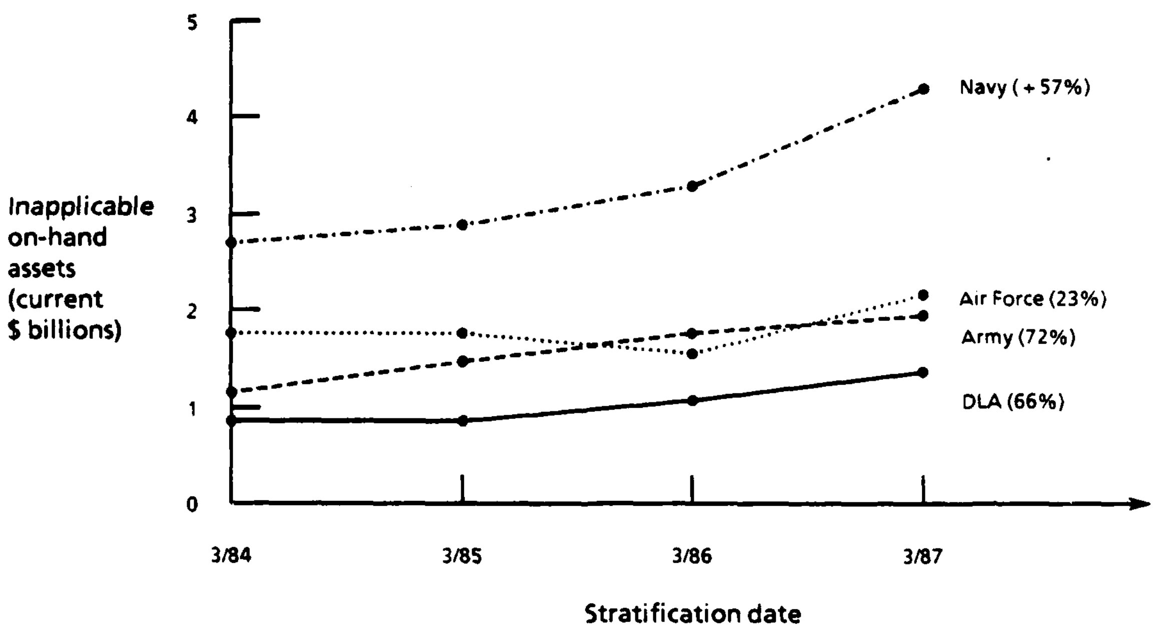
Figure C-1 shows the overall growth in inapplicable assets, both on hand and on order, for the Services and DLA combined. The current dollar value of inapplicable assets on hand has increased more than 50 percent from the FY84 level of $6.2 billion to $9.5 billion in FY87. On-order inapplicable assets have increased from $884.3 million to $1.8 billion in current dollars, an increase of over 100 percent.

The growth of inapplicable on-hand assets in each Service and DLA is presented in Figure C-2. Since FY84, on-hand inapplicable growth ranges from 23 percent in the Air Force to 72 percent for the Army. A similar analysis of on-order



Source: Service/DLA stratification data.

FIG. C-1. GROWTH IN INAPPLICABLE ON-HAND AND ON-ORDER DoD INVENTORY

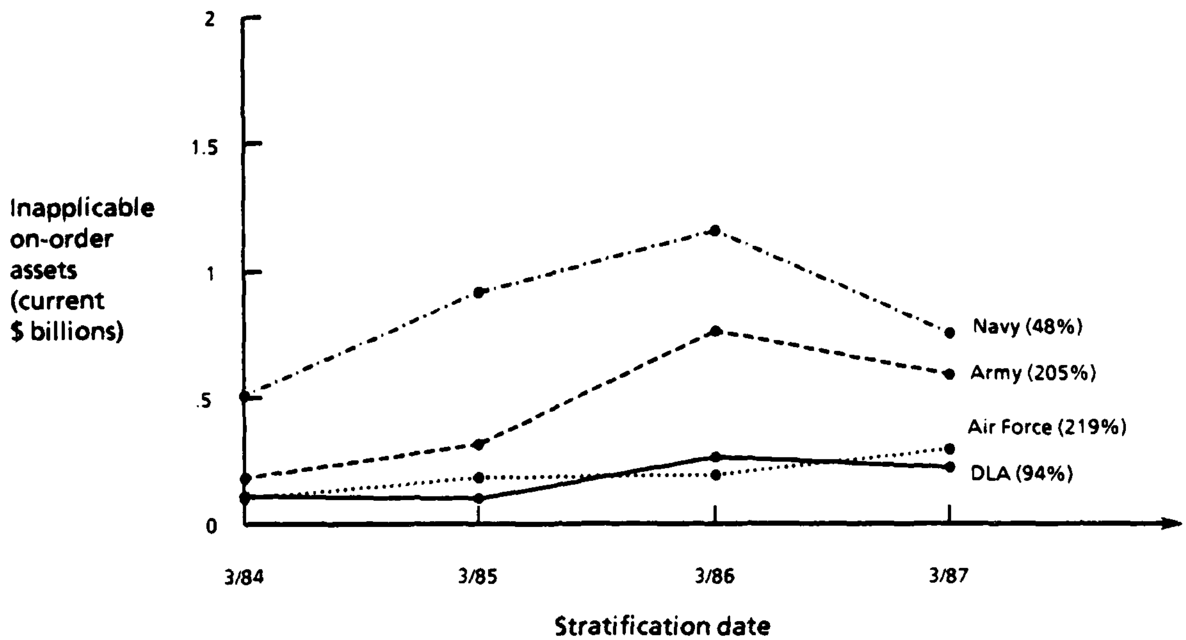


Source: Service/DLA stratification data.

Note: For Navy aviation reparables, outdated prices were indexed upward during this period as a part of the shift from appropriation funding to stock funding.

FIG. C-2. GROWTH IN INAPPLICABLE ON-HAND INVENTORIES

assets, shown in Figure C-3, indicates that the levels of inapplicable growth of on-order assets range from 48 percent for the Navy to 219 percent for the Air Force.



Source: Service/DLA stratification data.

FIG. C-3. GROWTH IN INAPPLICABLE ASSETS ON ORDER

Further, a comparison of inapplicable on-hand assets to total on-hand assets (Table C-1) reveals similar growth since FY84. In FY87, as a percentage of total on-hand assets, inapplicable on-hand assets represent 30 percent to almost 50 percent, depending on the Component measured. The trend since FY84 shows consistent growth in the percentage of inventory that is inapplicable.

Inapplicable on-order assets, when compared to total on-order assets, shows growth as well. As seen in Table C-2, current FY87 on-order inapplicable assets represent 8 to almost 12 percent of all on-order inventory. With the exception of the Navy, the portion of on-order assets defined as inapplicable approximately doubled for the Components since FY84.

Finally, Figure C-4 presents a consolidated picture of overall growth of DoD-wide inapplicable assets. Both on-hand and on-order inapplicable assets have trended upward since 1984. That trend is further reinforced by the fact that

TABLE C-1

INAPPLICABLE SERVICEABLE ON-HAND ASSETS AS A PERCENTAGE OF TOTAL ON-HAND ASSETS

DoD Component	FY84	FY85	FY86	FY87
Army	25.0	27.1	29.1	26.8
Navy	33.6	32.2	30.2	36.0
Air Force	42.7	44.7	45.8	48.2
DLA	22.9	20.0	26.1	27.9

Source: Service/DLA stratification data.

TABLE C-2

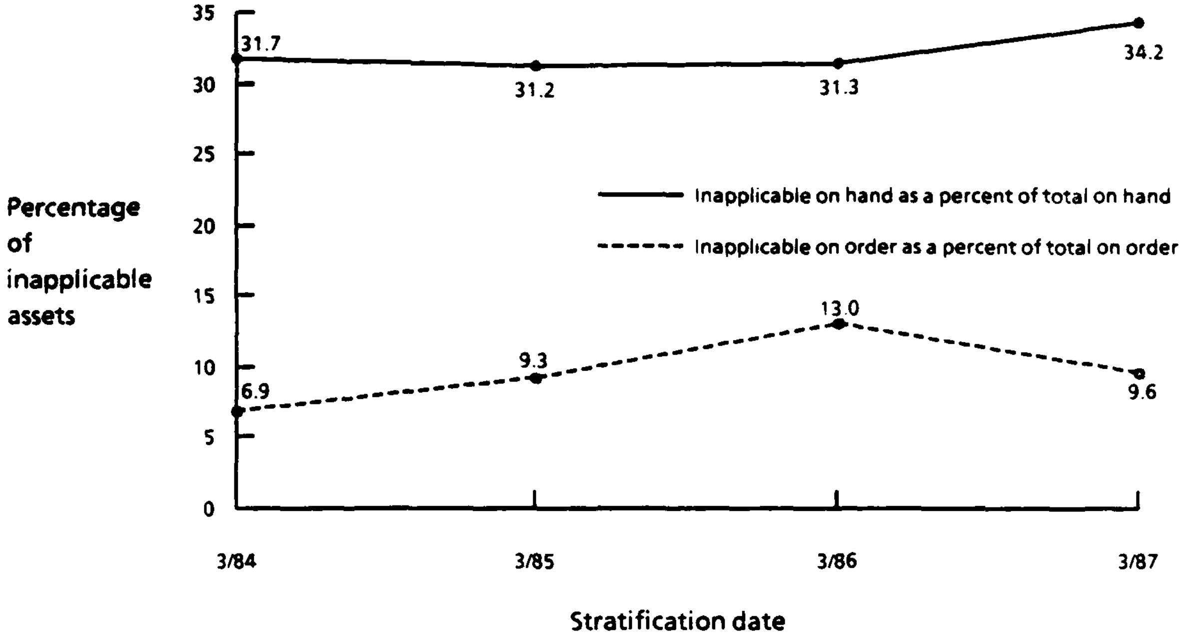
INAPPLICABLE ON-ORDER ASSETS AS A PERCENTAGE OF TOTAL ON-ORDER ASSETS

DoD Component	FY84	FY85	FY86	FY87
Army	4.6	5.9	12.9	8.3
Navy	10.0	13.0	14.3	10.0
Air Force	4.3	8.0	10.0	11.7
DLA	6.5	5.7	11.5	10.5

Source: Service/DLA stratification data.

inapplicable inventory is growing at a rate faster than total on-hand and on-order inventory, as shown in Table C-3. While overall on-hand inventory has grown about 40 percent since FY84, inapplicable on-hand inventory has increased just over 50 percent. Likewise, total on-order assets have increased approximately 49 percent while inapplicable on-order assets have increased slightly over 100 percent.

There are many possible reasons for the growth in inapplicable assets. Changes in total material requirements, unexpected changes in the asset picture (such as material returns) or changes in material usage or demand patterns may shift material (that was once applicable) above the AFAO threshold and into an excess position. In the following section, we examine some of the variables that



Source: Service/DLA stratification data.

FIG. C-4. INAPPLICABLE ON-HAND AND ON-ORDER ASSETS AS A PERCENTAGE OF TOTAL ON-HAND AND ON-ORDER ASSETS

TABLE C-3

GROWTH IN INAPPLICABLE INVENTORIES

(Dollars in millions)

Assets	FY84	FY87	Change (%)
On hand			
Total	$19,735.1	$27,717.1	+ 40.4
Inapplicable	6,246.9	9,488.0	+ 51.9
On order			
Total	12,745.9	19,003.1	+ 49.1
Inapplicable	884.3	1,833.4	+ 107.3

Source: Service/DLA stratification data.

affect overall inventory levels and potentially affect inapplicable inventory levels as well. In particular, we examine the potential effect of the increased order quantities associated with the minimum 12-month or annual buy programs that have been implemented by DoD Components.

LINE-ITEM ANALYSIS

Order quantity is one of the elements that make up the total inventory requirement and ultimately the AFAO. Therefore, a decrease in the order quantity decreases the requirement and the expected average on-hand inventory level, and conversely, an increase in order quantity raises the requirement and expected average on-hand inventories. In the following analyses, we examine the extent to which the relative size of the order quantity affects the potential for having inapplicable assets and, where inapplicable assets are present, the relative magnitude and growth of the inapplicable asset levels.

For our analysis, we use a line-item sample of specific stock numbers and analyze the change in their status that has occurred over a period of time. The items were originally selected for a study conducted by the Department of Defense Inspector General (DoDIG) of economic order quantities ("Minimum Economic Order Quantities," published 8 October 1987). The original data sample was drawn in March 1986 and includes items managed by eight Service and DLA inventory activities. In July 1987, we requested updated information on those items from the same eight activities, giving us a picture of the status of those items approximately 15 months later.

The DoDIG criteria for selecting these particular items was that they had been included in an annual buy program; that is, while their order quantities would normally compute to a quantity less than 1 year, their overall demand stability warranted their inclusion in the minimum 12-month or annual buy program and their order quantity had been increased to 1 year (12 months). The DoDIG estimated that 44,638 of the approximately 2.2 million items managed by these eight activities had been included in Service and DLA annual buy programs. The final DoDIG sample consisted of 888 of these line items.

Our subsequent data call resulted in a total of 789 pairs of usable inventory records. We omitted items from the sample if they were no longer managed by the original activity and if key data elements were missing in the second set of records.

A summary of the two samples along with the inventory activities included in the line-item analysis is presented in Table C-4.

TABLE C-4

SUMMARY OF INVENTORY ACTIVITIES AND SAMPLE SIZE

DoD Component	Sample 1	Sample 2
Air Force		
Warner Robins ALC	124	114
Sacramento ALC	116	94
Army		
AVSCOM	23	21
TACOM	92	77
Navy		
ASO	143	130
SPCC	92	80
DLA		
DISC	149	130
DCSC	149	143
Total	**888**	**789**

Note: Sample 1 is original DoDIG data drawn March 1986; Sample 2 is matching data drawn July 1987.

Changes in key management data for the two samples are shown in Table C-5. Annual demand, order quantities, and inventory levels are fairly stable. Safety levels have increased by 18 percent while administrative leadtime has increased by 11 percent.

These two samples also enable us to examine the change in both assets excess to the Requirements Objective (RO) and in inapplicable assets during this time period. As in the aggregate overview, we examined the level of inapplicable assets, that is, assets on hand and on order above the AFAO. In addition, we looked at changes in the asset levels relative to the RO. The RO is defined here as the level of requirements to which inventory is generally procured and consists of reorder point (procurement leadtime and safety level), the order quantity, and any material back orders. Assets on hand or on order excess to the RO are called "excess assets" in the discussion to follow. We used both measures to examine changes in asset positions in our data sample.

TABLE C-5

CHANGE IN INVENTORY STATUS

(In millions of dollars)

Sample size: 789

	1986 status		1987 status	
	Months	Dollars[a]	Months	Dollars[a]
Average inventory	11.6	49.1	12.8	48.5
Order quantity	12.2	63.2	12.6	64.8
Safety level	5.5	17.7	6.5	16.2
Administrative leadtime (ALT)	7.4	43.3	8.2	55.1
Production leadtime (PLT)	10.7	72.5	10.7	68.2
Annual demand value	-	62.8[b]	-	60.8[b]

Source: Service/DLA line-item sample data.

[a] Computed in 1987 dollars.

[b] Annual demand value of original DoDIG sample of 888 items in 1986 dollars is $55.6 million; 789-item sample value is $54.1 million 1986 dollars.

Table C-6 summarizes the changes in inventory position relative to both the RO and the AFAO between FY86 and FY87. In all sample comparisons, whether to the RO or AFAO, the incidence and dollar value of excess and inapplicable assets increased during this time period. Increases in excess and inapplicable assets on hand were larger than the increases of excess and inapplicable assets on order and percentage increases in the number of cases were generally greater than the increases in the dollar values.

Tables C-7 and C-8 compare our item sample to the aggregate data from which it was drawn. We included only consumable data in the aggregate, which corresponds to our item sample of consumables.

Table C-7 shows that the percentage of inapplicable on-hand assets is much higher for the aggregate stratification data than for our sample, both for FY86 and FY87. That discrepancy is not surprising since our item sample consists of high-dollar, stable-demand items that receive intensive management by the wholesale item manager. However, the data show that the percentage growth in inapplicable assets is considerably higher for our sample items. While inapplicable assets increased in the aggregate data from 37 percent to 38 percent, it more than doubled

TABLE C-6

NUMBER OF CASES AND DOLLAR VALUE OF EXCESS/INAPPLICABLE ASSETS

(Current dollars)

Assets	1986 data	1987 data	% change
On hand >RO			
Cases	90	255	+ 183
Dollars	$6.6 million	$14.2 million	+ 115
On order > RO			
Cases	297	371	+ 25
Dollars	$25.3 million	$32.4 million	+ 28
On hand > AFAO			
Cases	40	114	+ 185
Dollars	$2.9 million	$7.9 million	+ 172
On order > AFAO			
Cases	77	120	+ 56
Dollars	$8.5 million	$9.7 million	+ 14

Source: Service/DLA line-item sample data.

TABLE C-7

GROWTH IN INAPPLICABLE ON-HAND INVENTORY (CONSUMABLES ONLY)

(Current dollars in millions)

	Stratification data			789 – Item sample		
	1986	1987	% change	1986	1987	% change
Inapplicable	5,479.6	6,774.3	+ 24	2.3	7.9	+ 243
Total on hand	14,811.4	17,855.5	+ 21	55.8	76.1	+ 36
% inapplicable	37%	38%		4%	10%	

Source: Service/DLA stratification and line-item sample data.

for the sample items, increasing from 4 to 10 percent. Likewise, looking at the percentage change in inapplicable on-hand assets between FY86 and FY87, the growth for the aggregate data was 24 percent, and for our sample items it was 243 percent. In both cases, the growth of inapplicable assets was greater than that for total assets on hand.

TABLE C-8

GROWTH IN INAPPLICABLE ON-ORDER INVENTORY (CONSUMABLES ONLY)

(Current dollars in millions)

	Stratification data			789 – Item sample		
	1986	1987	% change	1986	1987	% change
Inapplicable	1,007.3	977.7	– 3	7.0	9.8	+ 40
Total on order	9,134.5	10,032.1	+ 10	134.9	158.8	+ 18
% inapplicable	11%	10%		5%	6%	

Source: Service/DLA stratification and line-item sample data.

Inapplicable on-order asset growth presents a similar picture (see Table C-8). While the percentage of inapplicable assets on order declined over the period in the aggregate data, from 11 to 10 percent, it grew in the data sample (from 5 to 6 percent). While the percentage change in inapplicable on-order assets declined by 3 percent for the aggregate sample, it increased by 40 percent in our 789-item sample.

Table C-9 shows the average order quantity as it was in 1986 and then in our second data call. For each item, we also computed an order quantity using actual order costs and holding costs associated with each inventory activity and the standard Wilson EOQ formula (described in Appendix E). This computation provides a relative comparison of the extent to which the order quantity has been increased as a result of the annual buy program. In the 1986 sample, the increase in order quantities for Army and Navy was roughly double with the implementation of the minimum 12-month order quantity policy while for the Air Force and DLA order quantities increased by more than 300 percent.

Actual order quantities in the 1987 sample, on the average, increased for the Army, remained stable for the Air Force and Navy, and decreased for the DLA items. The decrease in DLA order quantities corresponds to termination of the 12-month minimum annual buy program in the summer of 1986. Computed order quantities show little change over the period.

TABLE C-9

ITEM SAMPLE ORDER QUANTITY VALUES

Sample size: 789

DoD Component	1986		1987	
	Actual	Computed	Actual	Computed
Army	12.1	5.2	16.9	5.2
Navy	12.1	5.3	12.1	5.6
Air Force	12.1	3.5	12.2	3.4
DLA	12.1	3.8	4.8	3.9

Source: Service/DLA line-item sample data.
Note: Dollar weighted/constant dollars.

The data presented in Table C-10 give a more detailed picture of the changes in order quantity. Given that the annual buy program was in effect for these items, we did not expect to see much change in order quantities, with the exception of DLA which terminated its annual buy program. In fact, our sample data show that even where the average order quantity was stable between the two samples, considerable change took place at the item level. For many items, order quantities increased to a level above the 12-month order quantity level. Most of the overall decline in order quantities could be attributed to the DLA items.

Among the risks associated with the use of large order quantities (even when they are economically justified by, for example, a Wilson EOQ formulation) is that a decline in demand (and consequently a decline in requirements) will expose more assets to becoming inapplicable. Larger order quantities increase the average inventory levels and at lowered usage levels take longer to consume. Further, large order quantities directly reduce the flexibility of the inventory manager to adjust to demand changes in later buys.

We examined our data sample to determine relative demand patterns. Since these items had been identified by the wholesale manager as stable-demand items, we expected demand to be reasonably constant over the period encompassed by our two samples. What we found instead, however, was a striking variability in demand. As we see in Table C-11, of the 789 items in our sample, demand increased for 255 items (32.3 percent), declined for 512 items (64.9 percent), and remained the

TABLE C-10

CHANGES IN ORDER QUANTITIES

Sample size: 789

DoD Component	Increase	Decrease	No change
Army (n = 98)	41	5	52
Navy (n = 210)	93	56	61
Air Force (n = 208)	45	2	161
DLA (n = 273)	41	219	13
Total	220	282	287

Source: Service/DLA line-item sample data.

same for 22 items (2.8 percent). A further analysis, presented in Table C-12, shows the extent of these demand changes. Almost two-thirds of the sample experienced demand changes greater than 20 percent, either up or down. Of the 512 items with demand decline, two-fifths had demand drop off greater than 40 percent. The demand data we used were forecast demand, which is smoothed; actual demand variation would be even greater.

Because a drop in demand conceptually reduces the requirement and increases the likelihood of excess on-hand or on-order material, we examined our data to determine if that relationship held true. In the second set of data, we found a number of cases that had inventory on hand or on order above the RO and the AFAO even though they had none in the first sample. We separated those items into three groups: items for which demand had decreased, items for which demand had increased, and items for which no demand change had occurred. The results are presented in Table C-13.

The great majority of new cases of excess or inapplicable assets occurred, as expected, where demand had declined. A similar analysis was performed on a smaller group of items that had excess/inapplicable assets in the first sample and now had no excess or inapplicable assets . The analysis showed a similar effect. The

TABLE C-11

CHANGES IN DEMAND BY ACTIVITY

Sample size: 789

DoD Component	Increased demand	Decreased demand	No change
Army (n = 98)	39	57	2
Navy (n = 210)	94	109	7
Air Force (n = 208)	58	146	4
DLA (n = 273)	64	200	9
Total	255 (32.3%)	512 (64.9%)	22 (2.8%)

Source: Service/DLA line-item sample data.

TABLE C-12

DEMAND CHANGE IN ITEM SAMPLE

Sample size: 789

Demand change	Percent decrease					No change	Percent increase					
	81 to 99	61 to 80	41 to 60	21 to 40	1 to 20		1 to 20	21 to 40	41 to 60	61 to 80	81 to 100	Over 100
Number of items	29	58	110	151	164	22	95	45	33	20	7	55

Source: Service/DLA line-item sample data.

majority of items that were no longer in an excess position in the second sample had experienced demand increases.

To attempt to isolate the relative impacts of order quantity size, demand changes, and changes in other factors, we performed a multivariate analysis of the sample line-item data using standard multiple regression techniques. In performing this analysis, we examined a number of alternative variables that could potentially

TABLE C-13

IMPACT OF DEMAND CHANGE ON NEW CASES OF EXCESS/INAPPLICABLE ASSETS

Assets	Increased demand	Decreased demand	No change	Total new cases
On hand >RO	175	18	1	194
On order >RO	162	57	5	224
On hand > AFAO	86	3	1	90
On order > AFAO	90	6	5	101

Source: Service/DLA line-item sample data.

affect levels of excess/inapplicable assets. We present here only those variables that had a consistent effect on levels of excess and inapplicable assets. In the analyses, we used all the items in our sample, only those items with excess/inapplicable assets, only those items for which new cases of excess/inapplicable assets occurred, and only those items that had excess/inapplicable assets in both samples. We also conducted analyses using only data from the Services (which continued to use the 12-month or greater minimum order quantity floor).

All of the regression results presented in this section were evaluated for significance using the t-statistic of the coefficients of the independent variables and the F-statistic to show the significance of the relationship of the dependent variable to the independent variables. The significant independent variables in each regression table are noted with an asterisk; the F-statistics for all regressions presented here exceed the 95 percent confidence level unless otherwise noted.

Our analysis focused on three issues: (1) what factors explain or contribute to the incidence or likelihood of on-hand or on-order inapplicable asset conditions, (2) what factors explain or contribute to the relative magnitude of on-hand or on-order inapplicable asset conditions, and (3) what factors explain or contribute to the total percentage change in on-hand or on-order inapplicable asset conditions. The regression analysis compares the value of excess and inapplicable assets found in the second sample to the same values from the first sample. Hence, the regressions show the relationship between initial values of independent variables and the value of the dependent variable.

The most significant independent variables in predicting the incidence or magnitude of excess/inapplicable assets were those that relate to the change in demand or to the size of the requirement, including order quantity in months (EOQMOS), changes in order quantity (EOQPER), safety level (SL) in months, and total procurement leadtime (LT) in months. EOQMOS in the first sample is used in some of the initial regression runs presented, but for the majority of regressions, EOQPER was found to be a better predictor of excess/inapplicable assets. The dependent variables measured the level of assets on hand and on order greater than the RO or AFAO either in months or percent change. Key regression data are presented in this section along with discussion of the results. Complete descriptions of the regression results are presented in Table C-19 at the end of this section. Line numbers specified in Tables C-14 through C-18 correspond to those shown in Table C-19.

The first group of regressions shown in Table C-14 looks at what factors explain or contribute to the likelihood of excess or inapplicable assets and uses the entire 789-item sample. The dependent variable is the probability that an item is in an excess or inapplicable condition. An excess/inapplicable item was given a value of one; an item with no excess/inapplicable assets was assigned a zero. While the results of the regression are statistically significant, the R^2 values are fairly low in these analyses; that is, the four variables explain a relatively small percentage of the variance. In part, this is due to the large sample size. However, demand was a significant variable in all four cases; a decrease in demand was related to the probability that an item would become excess or inapplicable. The other variables, EOQMOS, SL, and LT were also significant in some of the cases.

The next group of regressions examine the factors that explain or contribute to the relative magnitude of excess or inapplicable assets on hand and on order. Given that an item was likely to be in an excess or inapplicable condition, we examined the variables that determined the magnitude of the excess or inapplicable assets. The dependent variable is the amount of excess or inapplicable assets on hand or on order, expressed in months.

In this analysis, we included only the items that had excess or inapplicable assets on hand and on order in the 1987 sample. The size of each sample depends on the number of items in the database with assets in excess of the RO or AFAO. The results of this analysis are presented in Table C-15. The percent of demand change

TABLE C-14

PREDICTING THE INCIDENCE OF EXCESS OR INAPPLICABLE ASSETS

Sample size: 789

Dependent variable	R^2 value	Independent variables and coefficients			
		Demand	EOQMOS	SL	LT
1. On hand > RO	.052	– 0.094[a]	– 0.003	– 0.000	– 0.006[a]
2. On order > RO	.028	– 0.065[a]	0.008	0.012[a]	– 0.001
3. On hand > AFAO	.055	– 0.089[a]	0.017[a]	0.004[a]	0.002[a]
4. On order > AFAO	.061	– 0.076[a]	0.025[a]	0.008[a]	0.003[a]

Source: Service/DLA line-item sample data.

[a] Statistically significant at the 95 percent confidence level.

was a significant variable in predicting the magnitude of the excess/inapplicable assets for the items with on-order assets greater than the RO or AFAO. The percent of change in the order quantity (EOQPER) was the most significant variable in three of the four regressions. However, the overall R^2 value for each of the runs was fairly low.

TABLE C-15

PREDICTING THE MAGNITUDE OF EXCESS OR INAPPLICABLE ASSETS FOR ALL DoD COMPONENTS

Sample: Items with excess/inapplicable on-hand or on-order assets

Dependent variable	R^2 value	Independent variables and coefficients			
		Demand	EOQPER	SL	LT
5. On hand > RO	.066	– 58.283	158.048[a]	0.983	1.120
6. On order > RO	.077	– 50.081[a]	47.192[a]	4.666[a]	1.998
7. On hand > AFAO	.057[b]	– 60.747	206.042[a]	– 0.586	0.849
8. On order > AFAO	.091	– 150.790[a]	44.745	6.911	1.990

Source: Service/DLA line-item sample data.

[a] Statistically significant at the 95 percent confidence level.

[b] F-test not significant.

We concluded that the low overall R^2 value for each run was in part due to the nature of our item sample, specifically the effect of the DLA items. During the period between our two data calls, DLA had terminated its annual buy program and the order quantities in the second sample were now smaller than those in the first sample. While overall our regression analysis shows that an increase in order quantities is related to the incidence of excess and inapplicable assets, the DLA items represent a case in which a decline in order quantities, to the extent that they affect the total requirement, also contributed to an increase in excess and inapplicable assets. By lowering the order quantity, the threshold for measuring excess and inapplicable assets is lowered as well. An examination of the sample confirmed this difference between the DLA and Service items. Two-thirds of the DLA items had a decline in the RO and one-third had an increase. For the Service items this relationship was reversed; one-third had a decline and two-thirds had an increase in the RO.

In Table C-16 we present the results of the same series of regression runs, omitting the DLA items from the sample. The R^2 values, even with the smaller sample size, are substantially improved, particularly for the comparison of on-hand assets. The effect of demand decline is consistently a factor; order quantity changes are the most important factor in predicting excess and inapplicable assets on hand.

TABLE C-16

PREDICTING THE MAGNITUDE OF EXCESS OR INAPPLICABLE ASSETS FOR THE SERVICES ONLY

Sample: Items with excess/inapplicable on hand or on order; Services only

Dependent variable	R^2 value	Independent variables and coefficients			
		Demand	EOQPER	SL	LT
9. On hand > RO	.374	- 24.802[a]	97.650[a]	5.181[a]	5.431[a]
10. On order > RO	.079	- 78.587[a]	37.185	6.151[a]	- 0.172
11. On hand >AFAO	.399	- 11.428	84.906[a]	8.034[a]	4.629[a]
12. On order >AFAO	.113	- 190.321[a]	30.810	9.619[a]	- 3.354

Source: Service line-item sample data.

[a] Statistically significant at the 95 percent confidence level.

This analysis and some analyses to follow show that the relationships predicting the magnitude of on-order excess/inapplicable assets are different from those predicting the magnitude of on-hand excess/inapplicable assets. Predicting on-hand excess/ inapplicable assets with these variables generally has a higher R^2 value than that for on-order excess/inapplicable assets. This may be due to the fact that when demand declines, on-hand levels accumulate and are drawn down only by continued usage or disposal. Excess/ inapplicable on-order assets, however, may be terminated (canceling the purchase order) or, more likely, are received and added to excess/inapplicable assets on hand.

In addition, the strength of the regression changes when we compare assets to RO rather than AFAO; generally, a stronger relationship (higher R^2 value) is found when comparing assets' positions to RO. This stronger relationship presumably exists because the RO is a smaller value and small changes in asset positions affect it before AFAO.

A third analysis of the factors influencing the magnitude of excess/inapplicable assets was performed using only new cases of excess and inapplicable assets. The sample comprised only those items that had developed excess or inapplicable on-hand or on-order assets since the first sample. These items had no excess/inapplicable assets in the first sample. In this way, the effect of any previously existing excess/ inapplicable assets was eliminated. The results are presented in Table C-17. Again, decline in demand and the growth in order quantity are positively related to the magnitude of excess and inapplicable assets.

In the last four regression analyses, shown in Table C-18, we examine the factors that contribute to the total percentage change, or growth, in excess/ inapplicable assets. The sample consists of items that had excess or inapplicable assets in both samples and for which we thus are able to calculate a percentage change. These are the smallest samples.

The R^2 values are reasonably good for predicting growth in on-hand excess/ inapplicable assets. For predicting excess to RO, the significant dependent variable is the percentage change in order quantity, while for AFAO, it is the demand change. Predicting growth in excess/inapplicable assets on order yields low R^2 values. As discussed earlier, it is presumed that on-order assets would not increase, but would be terminated or received.

TABLE C-17

PREDICTING THE MAGNITUDE OF EXCESS OR INAPPLICABLE ASSETS, NEW CASES ONLY

Sample: New cases

Dependent variable	R^2 value	Independent variables and coefficients			
		Demand	EOQPER	SL	LT
13. On hand >RO	.326	- 9.642[a]	39.546[a]	1.120[a]	0.804[a]
14. On order >RO	.222	- 9.941[a]	20.235[a]	0.697	2.675[a]
15. On hand >AFAO	.269	- 8.251	41.318[a]	0.878	0.878[a]
16. On order >AFAO	.148	- 31.929[a]	4.564	0.496	3.198[a]

Source: Service/DLA line-item sample data.

[a] Statistically significant at the 95 percent confidence level.

TABLE C-18

PREDICTING GROWTH (PERCENTAGE CHANGE) IN EXCESS OR INAPPLICABLE ASSETS

Sample: Excess/inapplicable in both samples

Dependent variable	R^2 value	Independent variables and coefficients			
		Demand	EOQPER	SL	LT
17. On hand > RO	.299	- 2.060	- 106.409[a]	- 1.062	- 0.125
18. On order > RO	.044[b]	- 59.209[a]	- 63.457	2.964	3.568
19. On hand >AFAO	.426	- 11.907[a]	- 4.720	- 0.031	- 0.554
20. On order >AFAO	.046[b]	- 39.510	- 14.680	- 1.759	1.286

Source: Service/DLA line-item sample data.

[a] Statistically significant at the 95 percent confidence level.

[b] F-test not significant.

LINE-ITEM ANALYSIS SUMMARY

The limitations of our analysis and results stem from the nature of our sample. All the items in our initial sample are part of an annual buy program with order quantities set at 12 months, and because of the lack of variation in the values, it was difficult to directly compare the effect of the larger (versus smaller) order quantities. A data sample that includes items with 12-month order quantities as well as items that are computed under the normal EOQ formulation would provide the basis for a more direct comparison. A second factor that affects the sample is the DLA termination of its 12-month buy program during our sample period and its return of order quantities in the second sample to the normal EOQ formulation. Lowering order quantities in itself may create excess/inapplicable assets at least until assets can be drawn down to normal levels again. Finally, a third factor that potentially limits the results is the relatively short time period, approximately 18 months. The initial asset position – how close an item was to the excess/inapplicable threshold at the outset – influences its position in the subsequent sample. Over a longer period of time, such differences in initial asset position would average out and the relative effect would diminish.

Despite the limitation of the item sample, the role of order quantity and demand in determining the incidence and magnitude of excess assets is established. As the order quantity increased and thereby increased the size of the requirement, the incidence and magnitude of excess/inapplicable assets increased accordingly. A larger requirement increases the exposure to excess and inapplicable assets when demand declines.

TABLE C-19

COMPLETE REGRESSION ANALYSIS RESULTS

	Dependent variable	Independent variables								R^2	Constant	Std. ERR	n	df	F
		Demand		EOQ		Safety level		Leadtime							
		Coefficient	Std ERR	Coefficient	Std. ERR	Coefficient	Std ERR	Coefficient	Std. ERR						
1	On hand >RO	-0.094	0.018	-0.003	0.012	-0.000	0.003	-0.006	0.002	.052	0.520	0.434	789	784	10.751
2	On order >RO	-0.065	0.021	0.008	0.014	0.012	0.003	-0.001	0.002	.028	0.388	0.494	789	784	5.646
3	On hand >AFAO	-0.089	0.014	0.017	0.010	0.004	0.002	0.002	0.001	.055	-0.038	0.343	789	784	11.407
4	On order >AFAO	-0.076	0.015	0.025	0.010	0.008	0.002	0.003	0.001	.061	-0.181	0.349	789	784	12.733
5	On hand >RO	-58.283	45.488	158.048	47.401	0.983	4.395	1.120	2.341	.066	25.603	394.844	255	250	4.345
6	On order >RO	-50.081	18.321	47.192	21.507	4.666	1.838	1.998	1.298	.077	-18.864	187.643	371	366	7.633
7	On hand >AFAO	-60.747	78.724	206.042	95.551	-0.586	8.379	0.849	3.886	.057	50.376	588.249	114	109	1.647
8	On order >AFAO	-150.790	72.944	44.745	54.940	6.911	4.115	1.990	3.582	.091	-52.434	311.331	120	115	2.878
9	On hand >RO	-24.802	15.033	97.650	23.143	5.181	1.581	5.431	1.611	.374	-97.543	117.691	136	131	19.566
10	On order >RO	-78.587	28.780	37.185	39.988	6.151	2.534	-0.172	2.168	.079	29.338	234.483	223	218	4.674
11	On hand >AFAO	-11.428	19.639	84.906	31.223	8.034	2.436	4.629	2.253	.399	-78.204	141.223	79	74	12.282
12	On order >AFAO	-190.321	89.073	30.810	81.623	9.619	4.960	-3.354	5.149	.113	62.475	347.033	90	85	2.707
13	On hand >RO	-9.642	5.391	39.546	5.615	1.120	0.528	0.804	0.271	.326	5.865	42.583	194	189	22.854
14	On order >RO	-9.941	5.912	20.235	6.809	0.697	0.666	2.675	0.438	.222	-15.288	48.861	224	219	15.623
15	On hand >AFAO	-8.251	8.452	41.318	9.771	0.878	0.894	0.878	0.387	.269	14.348	56.917	90	85	7.820
16	On order >AFAO	-31.929	18.055	4.564	12.463	0.496	1.119	3.198	0.887	.148	-21.015	68.535	101	96	4.169
17	On hand >RO	-2.060	22.437	106.409	24.090	-1.062	1.973	-0.125	1.327	.299	6.695	77.487	61	56	5.971
18	On order >RO	-59.209	35.461	-63.457	44.021	2.964	3.070	3.568	2.344	.044	-54.342	211.514	147	142	1.634
19	On hand >AFAO	-11.907	3.983	-4.720	5.866	-0.031	0.403	-0.554	0.335	.426	19.781	11.570	24	19	3.525
20	On order >AFAO	-39.510	69.187	-14.680	113.977	-1.759	2.937	1.286	3.841	.046	10.709	97.524	19	14	0.169

Source: Service/DLA line-item sample data

APPENDIX D

SOLICITATION AND USE OF ECONOMIC PURCHASE QUANTITIES

BACKGROUND

In August 1985, the Federal Acquisition Regulation (FAR)[1] was changed to require the insertion of a new clause in solicitations for supplies and repair parts integral to a major system. Promulgated by Federal Acquisition Change (FAC) 84-11 dated 30 August 1985, the clause essentially requests that potential suppliers advise the buying activity if the quantity solicited is considered uneconomical and provide the buying activity with the quantity (and related unit price) that the supplier believes to be an economical purchase quantity. In the FAR change, an "economical purchase quantity" is defined as "... that quantity at which a significant price break occurs and beyond which no substantial price decrease would result."

FAR guidance clearly indicates that economic purchase quantity (EPQ) data obtained as a result of the new clause is intended to "... assist inventory managers in establishing and evaluating economic order quantities for supplies under their cognizance." Thus, the intent of the FAR change is to provide information for future procurements, and the change stated that "Contracting Officers should generally take no action to revise quantities to be acquired in connection with the instant procurement." In those specific cases in which the economic production quantity data received in response to a solicitation are significant enough to warrant immediate consideration, the contracting officer, in consultation with the Inventory Manager (IM), can amend or cancel the solicitation and resolicit the higher quantity. Clearly, the FAR change does not address several major impediments to use of EPQ data obtained in solicitation responses:

- Service and agency inventory management files typically do not have the capability to store and use *multiple* price/quantity data in the development of order quantities.

[1]In accordance with Public Law 98-525, Section 2384a, dated 19 October 1984.

- The loss of processing/production time (in resoliciting economic production quantities) often negates part or all of the potential savings related to the lower purchase price and may well negatively affect customer support and materiel readiness.

- No consistent approved methodology exists for evaluating price/quantity data (in terms of overall cost to the Government) in applying the information to the actual buying decision.

At the time of the Department of Defense Inspector General (DoDIG) Audit of Minimum Economic Order Quantities (EOQs) in 1986 (DoDIG Project 65L-023), the DoDIG reported that seven of eight inventory control points (ICPs) visited had implemented the new FAR provisions. Details on how and when the FAR change was implemented were not provided in the DoDIG draft report. With respect to the development of an "...institutionalized systems approach to relate economic production quantity information to the purchasing decision models in use by the Services," the draft DoDIG report indicated that the Army Materiel Command (AMC) was developing a plan to accomplish the House Appropriations Committee (HAC) tasking as lead Service. At the time of the audit, AMC was coordinating policy issues within the Army staff and no interservice coordination had taken place.

To update and extend the previous analysis of EPQ implementation, this appendix reports the results of a more extensive review of EPQ solicitations and responses across all the Military Services and the Defense Logistics Agency (DLA).

MAJOR MANAGEMENT ISSUES

Based on the supporting background information outlined above, our analysis of the EPQ initiative includes both headquarters and field-level interviews as well as extensive review of contract history folders at 10 ICPs in Services and DLA. Our objective is to document actions they have taken to incorporate the solicitation and use of EPQ data in the order quantity decision for secondary items. To meet this overall objective, we examined five major issues:

- How and when did Service and agency ICPs implement the requirement that DoD invite potential suppliers to advise the Department of Defense (DoD) when order quantities are not "economic" based on production efficiencies and provide price-quantity information on economic production quantities?

- What response has DoD received to date from suppliers of secondary items based on the solicitation of EPQ information?

- How is EPQ being applied in the buying process for wholesale secondary items? What analytical techniques are used, what feedback is provided to the IM, what data are being incorporated into inventory management files, and how are order quantity decisions being finalized?

- What other factors (in addition to price and quantity) are being routinely considered in the solicitation and evaluation process? Is production leadtime a factor for evaluation? If so, how is leadtime information employed in the buying process?

- Finally, what action has been taken by the Army as "lead Service" in developing a consistent analytical methodology for evaluating alternative price and quantity pairs and are the methods developed adequate and appropriate to deal with these cost tradeoffs?

In combination, these five issue areas are addressed in the following analysis.

GENERAL RESULTS

Based on interviews with headquarters and field personnel, the following general implementation results are noted:

- The August 1985 FAR change was promulgated by headquarters units with no supplemental or specific guidance to the field. No special implementation instructions or reporting requirements were established. From a headquarters perspective, the solicitation and use of EPQ information by buying activities was viewed as another in a continuing series of changes in procurement regulations designed to reduce price and increase competition. While all headquarters components interviewed indicated that the FAR change had been implemented by their respective ICPs, none could specifically support that position nor identify the date when the FAR change first began to appear as a clause in solicitations. In fact, the FAR change was implemented by all ICPs surveyed.

- Results derived by the Service and agency ICPs from the solicitation of EPQs are negligible. For example, the Air Force has specifically included this item in Procurement Management Reviews (PMRs) conducted as selected Air Logistics Centers (ALCs) during 1987. In PMRs conducted at ALC Oklahoma City and ALC Warner Robbins, the Air Staff reports no responses were noted in the "fifty to one hundred" contract folders reviewed. Our analysis of contract history data across all Services and DLA supports this general observation. This poor response by vendors appears to arise from several conditions:

- The clause is buried in Section K (Certifications) of the solicitation and may not have been noted by vendors.
- Development of specific EPQ and price data by vendors takes time and resources and has no clear potential payoff. Consequently, it may not be done.
- Response to the clause is optional.

- Headquarters personnel interviewed were not cognizant of procedures established by their ICPs to use any economic production quantity data provided by vendors in responses to solicitations. Processing steps, buyer-IM communication, use in assessing order quantity alternatives, etc., were left to each individual ICP with no headquarters guidance or involvement. It is clear that there have been no major file changes or data systems changes to ICP inventory management and procurement systems which would allow a consistent use of these data in the buying process at the ICPs. Processing procedures that had been previously established by the ICPs to deal with quantity discount situations are being used to handle the few instances where economic production quantity data were provided.

- The Army effort to develop a common methodology for analyzing price/quantity alternatives is apparently floundering. AMC has developed a position paper and an approach and has forwarded them to Army staff level for review and approval. Discussions with AMC procurement personnel indicate the paper represents more of a policy position than a specific methodology. No inter-Service coordination has occurred.

IMPLEMENTATION TIMING

The timing of the implementation of the FAR EPQ clause varied significantly across the Components surveyed. As reflected in Table D-1, DLA activities implemented the clause in secondary item solicitations in the September 1985 through January 1986 time period. The Air Force implemented the FAR clause in November 1985. The Army, on the other hand, began implementation in November 1985 but did not fully implement the FAR provision until January 1986. Finally, the Navy was the last Service to implement the FAR EPQ clause in solicitations and did not complete implementation action until January 1987.

TABLE D-1

IMPLEMENTATION TIMING

Defense Component	Date FAR clause implemented in solicitations
Army	
AVSCOM	December 1985
CECOM	January 1986
MICOM	November 1985
Air Force	
Oklahoma City ALC	November 1985
Warner Robins ALC	November 1985
Navy	
ASO	January 1987
SPCC	April 1986
DLA	
DESC	December 1985
DGSC	September 1985
DISC	January 1986

Source: Service/DLA ICP survey data.

In all cases, the FAR clause was implemented in secondary item solicitations by updating mechanized processing system files used to prepare standard solicitation documents.

VENDOR RESPONSE

Based on our review of several hundred contract history folders at the 10 activities cited in Table D-1, the overall response by vendors to the FAR EPQ solicitation clause has been minimal to date. As shown in Table D-2, the aggregate vendor response rate is about 5 percent. For many of the activities surveyed, the rate of supplier response to the EPQ solicitation clause has been zero. Only two activities (AVSCOM and SPCC) reflected a meaningful response rate – 15 percent in both cases. This indicates some greater potential at these activities for increasing secondary item purchase quantities to meet vendor economic production thresholds. From this analysis, one must judge that either current order quantities for most items are above economic production levels or that vendors in general either fail to recognize the EPQ clause in secondary item solicitations or do not want to invest the resources necessary to provide EPQ information to buying activities. Analysis of the contract history files alone did not allow us to develop a position on these alternatives. However, given the positive responses noted to solicitations that included specific alternative buy quantities (or quantity ranges), we believe that vendors are generally willing to respond to EPQs only when the buying activity indicates specific interest in alternative quantities and when the solicitation makes it clear that the buying activity intends to actively consider an award of an alternative quantity.

TABLE D-2

VENDOR RESPONSE TO EPQ SOLICITATIONS

DoD Component	Number of contract files reviewed	Clause coverage	Vendor response	Response rate
Army				
AVSCOM	20	20	3	15%
CECOM	50	34	1	3
MICOM	25	25	1	4
Air Force				
Oklahoma City ALC	20	20	0	0
Warner Robins ALC	32	32	3	9
Navy				
ASO	28	28	0	0
SPCC	19	19	3	15
DLA				
DESC	23	22	0	0
DGSC	22	22	2	9
DISC	25	25	0	0
Total	264	247	13	5%

Source: Service/DLA ICP survey data.

EVALUATION SYSTEMS

In the absence of any coordinated DoD action to develop the systems needed to evaluate alternative price-quantity data in vendor proposals, the Air Force, Navy, and DLA have separately developed such capabilities. The Air Force and the Navy have developed "assessment models" for ICP use in evaluating alternative price-quantity pairs.

The Navy model (called Q Star) was developed jointly by the Navy Fleet Material Support Office (FMSO) and Navy Ships Parts Control Center (SPCC) and is currently still in a prototype stage at SPCC. Efforts to export the model to the Navy Aviation Supply Office (ASO) have not been successful to date, and ASO has been tasked by Naval Supply Systems Command Headquarters (NAVSUP) to formally review and comment on Q Star.

The Air Force model, which addresses the same problem, is in use at all ALCs for the evaluation of quantity discount alternatives. Developed jointly by the Air Force Logistics Command (AFLC) and outside contractors over a number of years, the model considers material acquisition costs, capital costs, storage costs, and obsolescence costs in recommending the "best" alternative to the buyer. If the resulting quantity differs from the order quantity recommended from the inventory management system, the IM is asked to document and formally request that the order quantity be changed as being "more economical" to the Government. The model is now a part of the Automated Contracting Information Processing System (ACIPS) and will be available in the Contract Data Management System (CDMS). Details of the model were provided by AFLC.

Finally, DLA Headquarters has developed guidance to its ICPs to evaluate quantity discount alternatives and has provided a PC-based program that incorporates the guidance. DLA has further directed that for those items which "consistently reflect price breaks," these PC-based optimum order quantities should be loaded as an override to the Supply Control File. Over time, they should be periodically validated. The underlying analysis supporting the minimum price breaks has not yet been evaluated.

Although the specific computational methods differ to some degree in these evaluation or tradeoff models, our analysis indicates that the approaches developed and, in many cases, now in use deal adequately with the costs and savings associated with buying a quantity larger than the computed order quantity. Moreover, these models allow the buyer in conjunction with the inventory manager to make full use of all available information at the time of the award to *selectively* adjust the buy quantity when, based on lowest total costs, that quantity is in the best interests of the Government. All of the systems analyzed operate in a "stand-alone" mode and are not currently integrated into the basic inventory management or requirements determination systems. Moreover, the price-quantity data collected for one procurement action is not routinely stored mechanically for use in later procurements of the same item. In addition, the models that have been developed and applied to date have not been formally reviewed or certified by any responsible audit group or agency such as the Defense Contract Audit Agency (DCAA) or the General Accounting Office (GAO). Finally, a question remains as to whether these methods or techniques as currently configured and utilized would be workable should the volume of solicitations analyzed increase substantially.

In spite of these unresolved questions and areas for further model development and streamlining, auditable, defensible tradeoff models exist and are being applied successfully to evaluate price-quantity alternatives on a selective basis at the time of the award. This dynamic approach to order quantity determination is a workable and cost-effective one for exploiting economic production savings and quantity discounts on a selective basis where documented net savings exist without incurring the significant costs and risks associated with the blanket approach used to date to deal with these issues.

APPENDIX E

DEVELOPMENT OF ECONOMIC ORDER QUANTITY PARAMETERS

THE WILSON ECONOMIC ORDER QUANTITY

The classic Wilson economic order quantity (EOQ) was derived to minimize total variable costs in a steady-state environment with known demand and procurement leadtime. It has proven useful for the management of a wide range of commercial and Government inventories even though the strict conditions of its mathematical derivation are rarely met. The Wilson EOQ, expressed in *units* to be ordered when the reorder point is reached, is as follows:

$$Q = \sqrt{\frac{2AP}{CH}} \qquad \text{Eq. E-1}$$

where: Q = Wilson EOQ in units,
A = annual demand in units,
P = cost to place an order,
C = cost of one item, and
H = annual rate of inventory holding cost.

The Wilson EOQ is used by the Services and DLA although it is sometimes formulated differently. For instance, each "hardware" inventory control point (ICP) in the Defense Logistics Agency (DLA) operates with an established T-value, which combines the values of order and holding costs. The T-value is used to compute an EOQ in *dollars* as follows:

$$T = 2\sqrt{\frac{2P}{H}} \qquad \text{Eq. E-2}$$

$$Q\$ = T\sqrt{\frac{AC}{4}} = T\sqrt{\text{value of one quarter's demand}}$$

DoDI 4140.39 includes "implied shortage cost" in the sum of total variable costs. In practice, the ICPs use the Wilson EOQ to minimize total variable holding and order costs. Since shortage costs are virtually never known in a military environment, that factor should not be included in the order quantity formula.

A more rational approach is to control supply availability through safety-level determination and focus order quantity calculations solely on minimizing holding and order costs. We recommend DoDI 4140.39 reflect that principle.

DEVELOPMENT OF CURRENT PARAMETER VALUES

The order and holding cost parameter values in the Services are reviewed annually and revised as necessary. In DLA, the T-values have not been changed since 1981. DLA Headquarters is currently reviewing alternative approaches to order and holding cost calculations and expects to provide specific guidance in 1989 to its ICPs concerning revision of their cost parameters. The Air Force EOQ factors are provided to the Air Logistics Centers (ALCs) by the Air Force Logistics Command (AFLC). The Army and Navy ICPs compute their own cost parameters with policy guidance from the Army Materiel Command and the Naval Supply Systems Command, respectively.

The OSD policy regarding EOQ parameters is contained in DoDI 4140.39. That instruction specifically addresses consumable items, but its guidance has also been applied to cost parameters for reparable items.[1]

The Services have made frequent adjustments to the values of the ordering and holding cost parameters used for order quantity calculations. Their calculations reflect, in varying degrees, the policy established in DoDI 4140.39. The DLA T-values were ostensibly tied to order and holding costs, but DLA personnel asserted that the T-values were largely determined by an attempt to set order quantities to control procurement workload.

Cost Parameter Policy

Order Costs

DoDI 4140.39 prescribes a detailed analysis of labor and ADP costs incurred in placing an order. The "industrial engineering" analysis requires a thorough review of the procurement process, including generation of the purchase request,

[1]Air Force reparable items were excluded from this study.

solicitation evaluation, contract administration, materiel receipt, and payment. Additional costs, including communications, document reproduction, and indirect personnel costs, are also supposed to be quantified.

The analyses performed by the Services to support order costs are ostensibly similar to the approach described in DoDI 4140.39. However, the enormous difference between official ICP order costs indicates an inconsistency in the computation of these costs, particularly given the substantial similarity between the procurement functions performed.

Holding Costs

DoDI 4140.39 specifies four elements of inventory holding costs:

- Investment cost – represents the time value of money
- Obsolescence costs – represents the effect of all factors that render materiel "superfluous to need"
- Other losses – represents pilferage, shrinkage, inventory adjustments, etc.
- Storage costs – represents "out-of-pocket" costs incurred in materiel storage and the amortized cost of warehouses.

DoDI 4140.39 specifies that investment cost and storage cost be set at 10 percent and 1 percent annual rates, respectively. These values are used by all Services and DLA, except for the Air Force, which has set its investment cost at 6 percent. The "other losses" factor used by the Air Force and some Army ICPs is 1 percent; it was not clear how they arrived at that value.

DoDI 4140.39 specifies obsolescence rates as "variable" but defines them as the value of transfers to disposals divided by the value of the maximum assets on hand or on order at any point in time. The obsolescence rate should be computed separately for each ICP and may be computed separately for different commodity groups managed by the ICP. The method prescribed in DoDI 4140.39 to establish obsolescence rates is not uniformly used today, and current obsolescence rates vary widely among ICPs.

The Air Force and some Army ICPs have greatly reduced their obsolescence rates in recent years and cite as their rationale the disposal-to-asset ratio. Navy obsolescence rates are the highest in DoD and have not been significantly changed for many years. The DLA T-values have not been changed since 1981, which implies the components of the T-values, including obsolescence, have been constant.

CURRENT PARAMETER VALUES

During the course of the study, we visited 10 ICPs. Their current order and holding cost values are shown in Table E-1 and depicted graphically in Figures E-1 and E-2. The order cost data shown are simplified to reflect the primary categories of "small" and "large" purchase used by the Services. Some ICPs have additional categories of procurements with distinct order costs.

TABLE E-1

ORDER QUANTITY COMPUTATIONAL PARAMETER VALUES

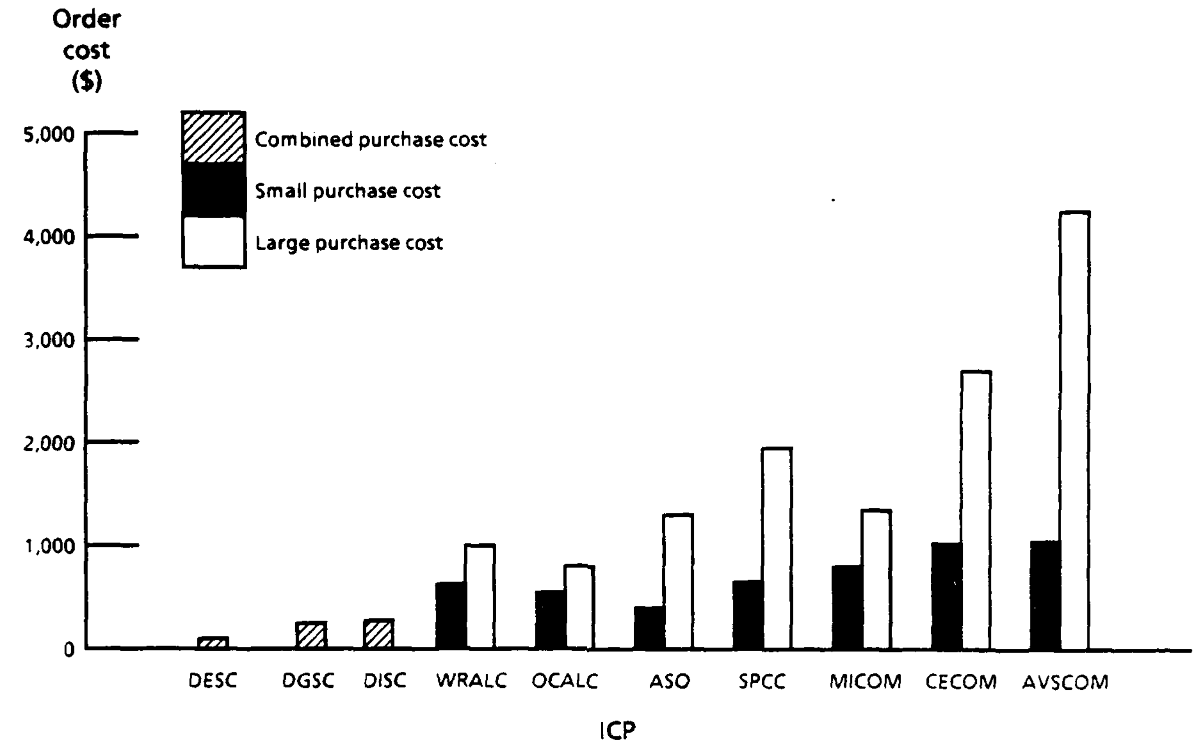
ICP	WRALC	OCALC	CECOM	MICOM	AVSCOM	ASO	SPCC	DESC	DGSC	DISC
Order cost:										
Small ($)	639	550	1,043	821	1,059	413	661	—	—	—
Large ($)	1,023	812	2,710	1,372	4,252	1,319	1,970	—	—	—
Combined ($)	—	—	—	—	—	—	—	103	250	298
Holding cost:										
Storage (%)	1	1	1	1	1	1	1	1	1	1
Capital (%)	6	6	10	10	10	10	10	10	10	10
Obsolescence (%)	4	3	4	1	2	10	12	4	9	7
Other (%)	1	1	1	1	—	—	—	—	—	—
Total holding cost (%)	12	11	16	13	13	21	23	15	20	18

Source: Service/DLA ICP survey data.

Notes: SPCC reparable holding cost shown; SPCC consumable obsolescence rate and holding cost are 2 percent less.

It would be desirable to refine and clarify the procedures for establishing the parameter values used in order quantity calculations. That need is evident considering the far-reaching impact of order and holding costs on order quantities and the significant range of values currently used at ICPs.

Central to the calculation of ICP cost parameters is the distinction between "fixed" and "variable" costs. DoDI 4140.39 defines fixed costs as those that may be judged to remain constant should 50 percent of the workload be eliminated. Since workload fluctuations of that magnitude from year to year at ICPs are extremely rare, a more reasonable criterion would be a remaining cost after a 25 percent



Source: Service/DLA ICP survey data.

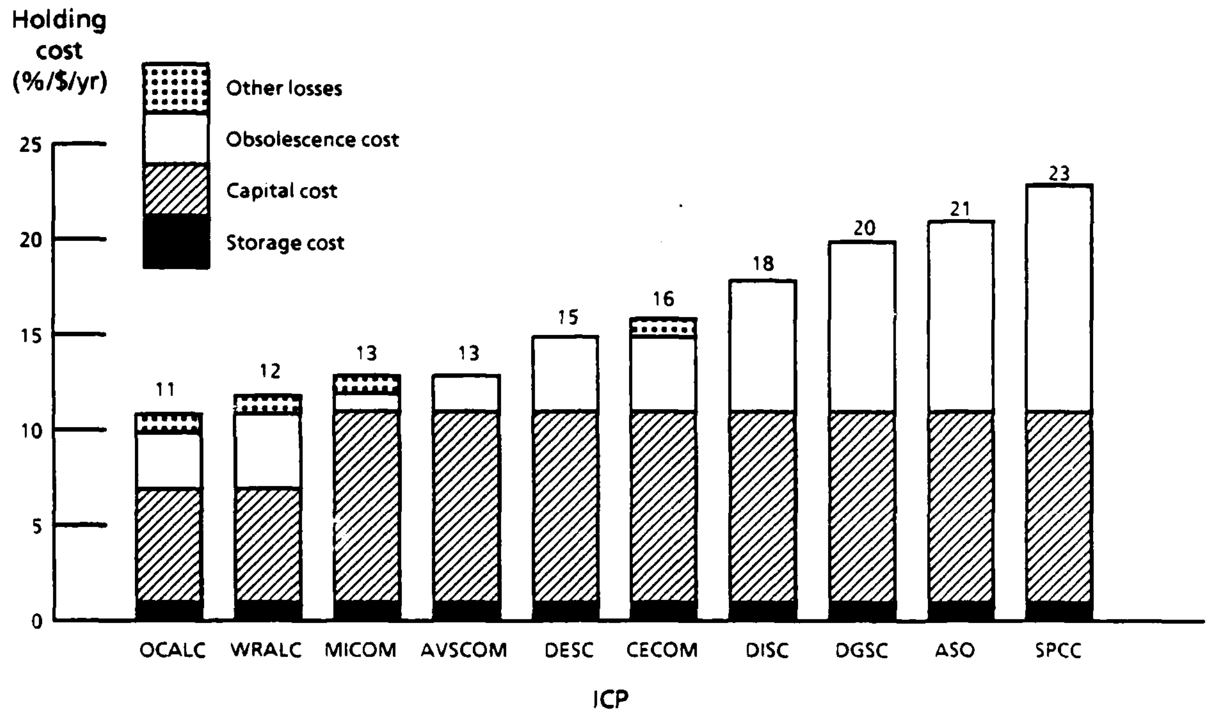
FIG. E-1. DoD ORDER COSTS

workload reduction. Overestimating variable costs can seriously distort order quantities.

PARAMETER VALUE CHANGES

While computational parameter values in DLA have been constant for many years, the Services have made large changes in both holding and order costs. Virtually all of those changes have increased order quantities, i.e., when holding costs have been changed they have been reduced and when order costs have been changed, they have been increased.

In the Air Force the most significant change was made in FY86 when the capital cost component of holding cost was reduced from 10 percent to 6 percent. The following year the Air Force made large reductions in its obsolescence rates, which vary by ICP.



Source: Service/DLA ICP survey data.
Notes: SPCC reparable holding cost shown; SPCC consumable obsolescence rate and holding cost are 2 percent less.

FIG. E-2. DoD HOLDING COST

The Navy's holding costs have remained constant in recent years, but its order costs more than doubled between FY84 and FY85. The cost of a competitive large procurement at ASO during that period increased by more than 460 percent.

Among the Army ICPs visited, the parameter value changes at AVSCOM were the most notable. Since October 1986, AVSCOM reduced its holding cost from 17 percent to 13 percent by eliminating the "other losses" factor and reducing the obsolescence rate from 5 percent to 2 percent. During that same period AVSCOM increased small and large purchase costs approximately 400 percent.

RECOMMENDATION FOR DETERMINING ORDER COSTS

The detailed analysis of the different parts of the process involved in ordering materiel, described in DoDI 4140.39, is a valid approach for capturing the *relative* magnitude of ordering costs for small and large purchase actions.

Within an ICP, the cost and difficulty of procuring different commodity groups may vary. Instead of a small versus large purchase distinction or only one order cost value per ICP in DLA, a finer breakdown of items managed could enhance the accuracy of the parameter values.

The enormous variance in order costs across the DoD suggests that the results of the detailed cost analyses should be "calibrated" by using actual procurement workload total variable costs associated with materiel procurement. A simple example of this is the following:

Total variable procurement costs:	$ 10,000,000
Number of procurement actions:	
Type A	12,000
Type B	2,500
Type C	800
Procurement costs from industrial engineering analysis:	
Type A	$ 538
Type B	$ 2,316
Type C	$ 4,685

Step 1: Compute cost indices (ratios) with lowest cost procurement indexed at 1.00.

			Cost index
Type A procurement		=	*1.00*
Type B procurement	*2,316 ÷ 538*	=	*4.30*
Type C procurement	*4,685 ÷ 538*	=	*8.71*

Step 2: Assuming "n" types of procurement actions, compute "calibrated" procurement cost for lowest cost procurement using total variable procurement costs.

$$\begin{aligned}
\textit{Calibrated lowest (Type A) procurement cost} &= \frac{\textit{Total variable procurement costs}}{\sum_{i=1}^{n}\left(\textit{Number of procurements of type [i]} \times \textit{Cost index of type [i]}\right)} \\
&= \frac{\$10{,}000{,}000}{(12{,}000 \times 1.00) + (2{,}500 \times 4.30) + (800 \times 8.71)} \\
&= \$336.50
\end{aligned}$$

Step 3: Compute calibrated costs of remaining types of procurement action using cost indices.

$$\textit{Cost of Type B procurement} = \$336.50 \times 4.30 = \$1{,}446.93$$

$$\textit{Cost of Type C procurement} = \$336.50 \times 8.71 = \$2{,}930.92$$

RECOMMENDATIONS FOR DETERMINING HOLDING COSTS

Capital Costs

The time value of money currently constitutes the largest component of holding costs at most ICPs. A rational indicator of that cost is the rate paid by the Government to borrow money. The rates are available weekly in the "Federal Reserve Statistical Release," which shows the current rates paid for Treasury Bills of different maturities. By using, for instance, the 12-month Treasury Bill rate, a moving average could be periodically calculated and the updated values provided to all ICPs. This approach would make inventory calculations responsive to broad trends in the real cost of capital. A moving average would dampen the effect of sharp changes in the rate, which could otherwise introduce excessive turbulence in order quantities.

The DoD policy on capital costs should be coordinated with the Office of Management and Budget (OMB). The current policy was based on OMB Circular A-94, which specifies a 10 percent discount factor to be used in Government economic analysis.

Obsolescence Rates

The present policy of defining obsolescence as the rate that materiel is transferred to disposal is not valid, particularly with the DoD-wide restrictions on disposal actions. According to DoDI 4140.39, the obsolescence cost should reflect all factors which render materiel "superfluous to need." To capture that rate, the measurement should be expanded to the *sum* of disposals plus the net growth in inapplicable on-hand assets (nonnegative), divided by on-hand assets. That is:

$$\begin{matrix}\textit{Obsolescence} \\ \textit{Rate}\end{matrix} = \frac{\begin{matrix}\textit{Value of disposals} \\ \textit{at standard price}\end{matrix} + \textit{maximum of}\left(O, \begin{matrix}\textit{Net growth in inapplicable} \\ \textit{on-hand assets}\end{matrix}\right)}{\textit{Value of on-hand assets at standard price}}$$

"Inapplicable Assets," for this purpose, are those assets in excess of the Approved Force Acquisition Objective (AFAO). To avoid unnecessary instability in the obsolescence rate, we recommend it be based on a 3-year moving average of the above measure.

Since real obsolescence rates for different items can differ significantly, obsolescence is appropriately measured independently by commodity group, based on weapon system application and/or Federal Supply Class. In addition to the standard measure proposed above, the Inventory Manager should adjust the rate as appropriate when special information is known about a system. Relevant information would include system replacements, phase-outs, or major modifications. Those factors increase real obsolescence rates.

Storage Costs and Other Losses

The guidance in DoDI 4140.39 should be expanded to provide for the computation of costs for storage and other losses by individual commodity groups. The method of segmenting an inventory for this purpose should not be the same as that used for determining obsolescence rates. Federal Supply Class and physical criteria, e.g., dimension, weight, or special storage requirements, should be used when considering costs for storage and other losses. Weapon system application is probably not a relevant factor for this purpose.

SUBMISSION OF COST DATA

Stratification reports are the key summaries of secondary item assets and requirements. To accurately interpret the requirements portion of the stratification reports, it is essential to know the value of the cost parameters used in order quantity calculations.

A standard format should be used to report order and holding costs. All four categories of holding cost identified in DoDI 4140.39 should be quantified and reported. Currently, many ICPs do not include the "other losses" factor in their holding costs. However, no ICP claims to have completely eliminated losses due to "pilferage, shrinkage, inventory adjustments, etc." This factor should be explicitly included with obsolescence, investment, and storage costs when computing and reporting holding costs.

In view of the differences among ICP procurement operations, the reporting of order costs should be flexible enough to address the distinct categories of procurement actions relevant to different ICPs. However, to facilitate the interpretation of these data, the following standard data should be provided for *each type* of procurement action:

- Order costs
- Number and value of procurement actions during the previous 12 months
- Anticipated number and value of procurement actions during the next 12 months.

We recommend that the stratification reports include a summary of the order quantity calculation, holding and order costs, an explanation of how the cost parameters were computed, and the constraints that were applied to the calculation of order quantities.

The explanation of costs computation should include both the methodology employed and the values of the key variables used in the calculation.

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